23, 103/B/ii.1

Companion of my lonely hours
~~Who faithful [illegible] the weary time~~

~~My little timepiece what a pleasure~~
~~To have thee always near at hand~~

Little timepiece what a pleasure
To have thee always near to me
The weary hours of pain to measure
The fleeting lapse of time [illegible]

~~Through the lingering day~~ night
~~Thy ceaseless tick to me appears~~ —
To beat the silence
Unwearied you [illegible] ~~[illegible] companion~~ —
Tick ~~through~~ ~~the~~ silent hours of night.

Unwearied through the silent hours —
~~of night your tick~~
of night you beat the ~~[illegible]~~ [illegible] —
of night your [illegible] [illegible] —
And seem to break the long silence

Sweet solace of my lo

Cea

Companion of my lonely hours

trees
Through the bright dusky ~~twilight~~

Through nights to be of dusky [illegible] —
They bend above the sullen brooks —
With many teeth are

Through

The nights also be dusky —
They bend above the sullen brooks —
~~[illegible] [illegible] below by [illegible]~~ day —
~~[illegible] [illegible]~~
and

A
GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE.
&c. &c.

Though the [illegible]

Though by [illegible] —
[illegible] the [illegible] —

[illegible] they by fast [illegible]

Then

Thee [illegible]

Thee

Jay

Thee by [illegible] [illegible] and [illegible]

Thy

47293

A
GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE;
AND ITS
APPLICATION
TO THE
PHENOMENA OF NATURE AND ART.

BY A. F. FOURCROY,

Of the National Institute of France, Counsellor of State, Professor
of Chemistry at various Public Establishments, Member
of many Academies, &c.

IN ELEVEN VOLUMES.

TOGETHER WITH A SET OF SYNOPTIC TABLES, IN LARGE FOLIO.

TRANSLATED FROM THE ORIGINAL FRENCH,

BY WILLIAM NICHOLSON.

VOL. VIII.

LONDON:

PRINTED FOR CADELL AND DAVIES, STRAND; LONGMAN
AND REES, G. AND J. ROBINSON, AND J. WALKER,
PATERNOSTER-ROW; VERNOR AND HOOD, POULTRY;
CLARKE AND SONS, PORTUGAL-STREET; CUTHELL
AND MARTIN, AND OGILVY AND SON, HOLBORN;
AND S. BAGSTER, STRAND.

1804.

W. Flint, Printer, Old Bailey.

[illegible] through the night long –

[illegible] along ~~the Stream~~

They [illegible] [illegible] [illegible] the [illegible] [illegible]

[illegible]

[illegible] [illegible]

They [illegible] ~~[illegible]~~ the [illegible] [illegible] [illegible]
Above the [illegible] [illegible] [illegible] –
~~[illegible]~~ –
[illegible] !

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A
SYSTEM
OF
CHEMICAL KNOWLEDGE.

CONTINUATION OF THE
SEVENTH SECTION.

Article IV.

Concerning the Eleventh of the immediate Materials of Vegetables.

Of Camphor.

A. *Situation.*

1. CAMPHOR was not formerly conſidered as one of the immediate materials of vegetables, but merely as a principle peculiar to that tree of Molucca which affords it. Slare and Ludovic firſt obſerved it in old oil of Canella; Kunckel in the thick oil of anniſeed and roſemary; Cruger in oil of marjoram kept twenty-ſeven years. Geoffroy has extended and confirmed theſe obſervations by aſcertaining the exiſtence of camphor in many eſſential oils, and obſerved that it falls down in the courſe of time from them,

particularly from the oils here mentioned. After theſe chemiſts, Cartheuſer diſcovered it in a great number of plants. Prouſt has accurately deſcribed the art of extracting it, even with profit, from various ſpecies of volatile oils, which grow abundantly in the province of Murcia.

2. The tree which affords camphor is a ſpecies of laurel, which grows abundantly at Ceylon, at Borneo, and in the iſland of Java. It alſo exiſts in the roots of canella, zedoary, ſaſſafras, in the oils of thyme, roſemary, ſage, lavender, marjoram, and matricary. Citizen Joſſe, apothecary at Paris, has obtained it in ſufficient quantity to aſcertain its nature from the roots of elicampane: I have found very evident traces of it in the roots of Valerian. It exiſts in general in various volatile oils, which hold it in ſolution, and ſuffer it to precipitate, either by ſpontaneous evaporation or by the action of fire. Many chemiſts affirm, that thyme and pepper-mint, ſlowly dried, afford much camphor by diſtillation. Mr. Achard has obſerved, that a ſmell of camphor is diſengaged when the volatile oil of fennel is treated with nitric acid; that the oil of anniſeed afforded it in cryſtals by the ſame acid; and laſtly that vinegar, charged with oil of angelica, let fall camphor by the addition of pot-aſh.

3. All theſe facts united, leave no doubt reſpecting the exiſtence of camphor in a great number of vegetables. There is reaſon to think

that it will be ſtill more abundantly found when experiments ſhall be multiplied on this head. We muſt not therefore any longer conſider camphor as a principle peculiar to any ſingle vegetable, but truly as one of the immediate materials of plants among which it ought to be arranged.

B. *Extraction.*

4. NOTWITHSTANDING the exiſtence of camphor, as it appears in many vegetables, that which is moſt abundantly employed, becauſe moſt eaſily extracted, is obtained in the Moluccas from the laurus-camphora of Linnæus, or the camphorated laurel. This tree grows ſpeedily, and in great numbers, in the iſlands of Sumatra, Borneo, Java, and in Japan. Many travellers aſſert, that this tree contains it ſometimes in ſo great quantity, that nothing more is neceſſary than to ſplit it, in order to obtain conſiderable maſſes in a pure ſtate. It is obtained from this vegetable by diſtillation. The roots and branches of the camphor-bearing laurel are put into a great alembic with water. A head is adapted, the inner part of which is fitted up with ſtrings made of rice-ſtraw. The heat which is applied volatilizes and ſublimes the camphor, which adheres to the cords in the form of ſmall greyiſh, dirty grains, which are united by rubbing into larger pieces. The

camphor thus collected is impure. It is refined in Holland by ſublimation, in which one-ſixth of its weight of chalk is uſed. Some perſons aſſure us that this operation is made without any addition in galleries placed over long furnaces conſtructed on a ſlope, in which the fire is kept up by letting fall ſucceſſively in the direction of thoſe fires the membranous envelops or chaff of buck-wheat, *polygonum fagopyrum.* Theſe envelops of the ſarrazin are ſeparated by ſwelling with water, and the ſubſequent effect of a gentle heat. They take fire with rapidity on account of their dryneſs.

5. To theſe accounts of the ancient art of extracting camphor from the laurel, it is neceſſary to add in this place a ſhort notice of operations reſpecting the extraction of camphor from various volatile oils, being part of a diſſertation of Mr. Prouſt, a French chemiſt, Profeſſor at Segovia ſince 1784, publiſhed in Spaniſh in that town in 1789, under the following title: *Reſultado de las experiencias hechas ſobra el alcanfor de Murcia. Conlicencia en Sigovia pordon Antonio Eſpinoſa.* I ſhall follow a very ample extract inſerted by Mr. Arezula, a Spaniſh chemiſt, one of my pupils, in the Annals of Chemiſtry, vol. iv. p. 179. Mr. Prouſt having obſerved, in a bottle of volatile oil of lavender, different ramified cryſtals formed of octahedrons, placed upon each other, and a kind of ſnow depoſited on that part of the bottle where the oil had been ſpilled on the outſide, thus

diſcovered the preſence of camphor in the oil, and ſuſpected that it exiſted alſo in thoſe of various other labiated plants of Murcia, a province very fertile in this genus of plants, and which afford much of the volatile oils of commerce. A continuation of his inquiries ſoon ſhowed, that evaporation in the open air is a very proper means to ſeparate the camphor from theſe oils. At a temperature between 6 below 0, and 10 above 0 of the thermometer of Reaumur, he expoſed it to the air in plates of porcelain, in a ſtill place, conſiderable quantities of oil of roſemary, of marjoram, of ſage, and of lavender from the country here mentioned. Spontaneous evaporation was ſufficient to afford him camphor in cryſtals, one-ſixteenth of the weight of that of roſemary, near one-tenth of that of marjoram, nearly an eighth of that of ſage, and upwards one-fourth of that of lavender. He did not, however, keep any account of that which was diſſipated with the oil volatilized in the air: ſo that thoſe quantities, though conſiderable, are ſtill leſs than was contained in the oils themſelves. The oil of lavender, the moſt rich in camphor, afforded a firſt portion of this body ſeparated after twenty-four hours; it had the form of blades intertwined together, and he ſeparated the portion of oil which adhered by mere ſuſpenſion in a funnel. At fifteen degrees the ſpeedier evaporation cauſed the camphor of this volatile oil to ſeparate after twelve hours expoſure to the air. In very hot ſeaſons, the diſtilled oil carries ſo much with it that it depoſits it in cooling; and an apothecary of Madrid aſſured Mr. Arezula, that by this ſimple proceſs camphor had long been obtained from the volatile oils of Murcia, and was ſold for thirty ſous the *(quantity not mentioned in the original)* in commerce. The volatile oil of ſage depoſits its camphor rather more ſlowly than that of lavender, and it is more difficult to ſeparate the portion of oil which hangs about it. The camphor thus obtained and dried on blotting paper was dry, white, and brilliant, like ſnow; it ſcarcely exhibited the odour of the oil from which it was afforded.

By diſtilling the oils of lavender on a water-bath of conſiderable extent, but ſhallow, placed at ſome diſtance from water kept at the heat of ſeveral degrees below the boiling point, until a third of theſe fluids is drawn over, and the apparatus being then left to cool, two-thirds of that which remains in the veſſels are obtained, conſiſting of camphor cryſtallized and precipitated, which may be taken out with a ſkimmer, then drained in a ſieve, or ſlightly compreſſed. The remaining oil is to be treated with other water as before. The heat of the ebullition and the diſtillation, urged ſtill farther, cauſe the camphor to riſe by ſublimation in the head. When the operation is thus finiſhed, one half of the camphor contained in the oil will have been obtained. Three ſucceſſive operations are ſufficient to deprive oil of lavender of the camphor it is capable of affording. It is not poſſible to obtain by this means more than a fifth, inſtead of the fourth part which it really contains.

The reſidue contains a ſeventy-ſecond part, and the diſtilled oil ſix of the ſame parts. Mr. Prouſt eſtimates, that in the large way this oil will not afford more than fifteen parts out of ſeventy-two of camphor, inſtead of eighteen, which it in fact contains.

By refining the camphor thus obtained by ſublimation, the profeſſor of Segovia made ſeveral important obſervations. Twenty-four parts of this product afforded him only twenty-two of very white ſolid and pure camphor. The two twenty-fourth parts which remained were too ſtrongly heated, which rendered them of a brown-red, owing to a reſinous ſubſtance, which, having been taken up with the alcohol, was precipitated by water of a tenacious and reddiſh appearance, whereas the camphor itſelf was precipitated in white flakes. This reſin ariſing from a ſmall quantity of oil remaining between the cryſtals of the camphor in the firſt operation, prevented the ſublimation of the laſt portion, Lime facilitated its purification, and afforded twenty-three twenty-fourth parts of white dry camphor. Waſhed aſhes ſucceed equally well. White clay afforded yellow camphor. He adviſes the uſe of lime or waſhed wood-aſhes in preference to the clay, which he rejects. It is neceſſary that theſe ſubſtances ſhould be very dry, becauſe the water they contain produces a boiling in the mixture, the projected fluid from which would ſoil the ſublimed camphor. Fire of conſiderable ſtrength, and ſhallow veſſels, contribute much to afford the camphor in white ſolid loaves, as it ought to be for the market. The fuſed camphor may be boiled before the ſublimation, becauſe it is leſs volatile than the oil, and a ſtronger heat is required to raiſe it than would be ſuppoſed, from the ancient notions reſpecting the volatility of camphor. This is the only means of obtaining it tranſparent and in maſſes; and it appears that this is the ſecret of the Dutch refineries. The ſublimed camphor contracts in cooling, and breaks in various places; it ſeparates very well from the veſſel; whereas, when leſs heated, it is lamellated, rous or ſpongy, and adheres much.

The author, from the ſimple and preciſe calculations founded on the price of oil of lavender, the camphor of Murcia, and the charges of the operation which he deſcribes for extracting and refining camphor, compared with the product he obtained, concludes that the advantage would be from ſixty to ſixty-three per cent.

Oil of ſage treated in the ſame manner as that of lavender, though it requires but one third of the product to be volatilized, does not afford, according to him, more than a profit of twelve or thirteen per cent. on account of the leſs quantity of camphor it contains; the oil of marjoram affords between ten and eleven per cent. and that of roſemary ſtill leſs, as it does not exceed four or five per cent.

Mr. Prouſt concludes this intereſting reſearch with a compariſon of the properties of the camphor extracted from the oil of lavender of Murcia with thoſe of the camphor of commerce, and he found the effects of the nitric acid upon the one and the other to be abſolutely the ſame. Each furniſhed, after having precipitated them from the nitric acid by means of water, a loſs of thirty-five per cent. concerning which I ſhall ſpeak hereafter.

6. Theſe intereſting details afford reaſon to preſume that much advantage might be derived from the labiated plants which grow ſo abundantly in the ſouthern departments of the French Republic, and particularly from the greater lavender, *lavendula ſpica*, the ſame as that of Murcia from which the oil of aſpic is extracted. Though the difference of climates might produce ſome modification in the quantity of the product, there is reaſon to hope that this oil, ſo abundant and ſo cheap in compariſon with the other volatile oils, would afford camphor by the proceſſes of Mr. Prouſt, and thus ſupply us with a new article of trade, for which the nation would no longer be under the neceſſity of paying to foreigners in ready money.

C. *Phyſical Properties.*

7. VERY pure camphor is a white, concrete, tranſparent body, cryſtallized in octahedrons or ſquare plates, of which the ſpecific gravity is in compariſon to water, upon which it floats, as 9,887 to 10,000. Its taſte is acrid, hot, penetrating,

netrating, and bitter. Its ſtrong and diſagreeable ſmell gave riſe to the adage of Salerneum, *Camphora per nares caſtrat odore mares*, becauſe it has long been ſuppoſed to poſſeſs a calming and ſedative property; but it is very far from poſſeſſing that property to the extent denoted in that verſe.

8. When it is placed in fragments, even of conſiderable magnitude upon water, the fluid moves round the fragments, and circulates as if it gradually attacked their ſurface. Small cylinders of camphor, placed vertically in water ſo as to ſtand above its ſurface, but alſo fixed in ſuch a manner as to remain in part beneath, are cut in two, according to the obſervation of Venturi, Profeſſor of Natural Philoſophy at Modena, at the preciſe level of the water. Very ſmall pieces of camphor thrown upon water are agitated, and moved about with great rapidity. A drop of oil let fall upon the ſurface of the liquid immediately ſtops the motion, which was erroneouſly attributed to electricity, but appears to be owing to the attraction of the particles of camphor, water, and air, and to be a true combination between theſe three bodies.

9. Camphor is one of the moſt volatile ſubſtances we know; it appears nevertheleſs, from the experiments of Prouſt, to be leſs ſo than volatile oil. But we muſt not overlook that this is to be underſtood reſpecting its combination with the oils, and not with regard to pure and inſulated camphor. Camphor in a cloſed

veſſel, expoſed to a temperature ſuperior to ſixteen degrees of Reaumur's thermometer, continually riſes in vapour, and is inceſſantly ſublimed. The upper part of the ſides of the veſſel is found to be covered with cryſtalline grains of camphor variouſly grouped upon the ſurface of the glaſs. It appears in this caſe, that the heated air diſſolves it, and afterwards, by cooling, depoſits it on the ſides of the veſſel.

10. Camphor is alſo fuſible at a temperature, which Citizen Venturi eſtimates at 120 degrees of the thermometer of Reaumur. Mr. Prouſt deſcribes it in a ſtate of fuſion and ebullition before it riſes in vapour. In fact we may ſuppoſe that the twenty-fourth part of volatile oil, to which it was ſtill united, had an influence on its fuſion, notwithſtanding its ſmall quantity. In this ſublimation, the camphor cryſtallizes in a different manner from that which it exhibits when it abandons its oily ſolvent, and a few traces of octahedrons are perceivable only in the caſe of its volatilization in ſmall irregular grains. Citizen Venturi affirms, that it ſublimes at fifty degrees of the thermometer of Reaumur. According to the ſame philoſopher, it evaporates at the ordinary temperature of the atmoſphere in the vacuum of the barometer.

D. *Chemical Properties.*

11. While it preſents ſome analogies with the volatile oils, camphor exhibits very remarkable differences. When placed in contact with a burning body, it takes fire briſkly, and emits a very white flame with abundant fumes. Citizen Lagrange burned it in oxigen gas or mercury, in the ſame manner, as Lavoiſier burned carbon and phoſphorus. He obtained much ſublimed charcoal, carbonic acid gas, and another acid, of which the nature is not accurately determined, but which he compared to the camphoric acid. By diſtilling camphor ground with alumine, in order to fix it in a certain reſpect, he extracted a golden-yellow coloured oil, of an acrid taſte, and of a ſmell reſembling that of thyme and roſemary, volatile in the air, forming a liquid ſoap with the cauſtic alkalis, ſoluble in alcohol, becoming white in the oxigenated muriatic acid: a very black and very pure coaly matter remained in the alumine. According to the ſame chemiſt, a ſmall quantity of camphoric acid is formed during the diſtillation of camphor.

12. The union of the ſimple combuſtible bodies with camphor, particularly phoſphorus and ſulphur, has not been yet examined. Water diſſolves it in a very ſmall quantity, which, however, is ſufficient to produce a very perceptible acrid ſmell and taſte; when camphor is burned

upon water, the fluid contracts a very perceptible acid taſte, and other properties.

13. One of the great differences between campor and the volatile oils, is the manner in which it is affected by the ſtrong acids. Concentrated ſulphuric acid diſſolves it, and by the aſſiſtance of heat, ſulphureous acid and hidrogen gas are diſengaged; the fluid becomes of a violet or brown-red; and it is aſcertained that carbon is ſeparated, and water with an acid is formed. The nitric acid diſſolves it effectually, if it be but little concentrated. This yellowiſh ſolution ſeparates into two liquids; that which floats above has been improperly denominated *oil of camphor;* the portion beneath contains camphor already altered and acidified; for when the upper fluid is precipitated by water, which ſeparates camphor in the ſolid ſtate without alteration, more than a third of this combuſtible body is found to have diſappeared. The gaſeous muriatic acid alſo diſſolves camphor, and puts it into the aëriform ſtate; the ſame is the caſe with the fluoric acid gas. Water precipitates the camphor of theſe ſolutions in the ſolid ſtate, as it does the nitric ſolution.

14. Mr. Koſegarten long ſince diſcovered that the nitric acid, diſtilled in a conſiderable quantity from camphor, converts it into a peculiar acid. Citizen Bouillon has confirmed this diſcovery, and carried his reſearches concerning this acid much farther. In order to obtain it, eight parts of nitric acid, at thirty-ſix degrees,

are poured upon one part of camphor in a glaſs retort. Heat is given by a ſand-bath, and much nitrous gas with carbonic acid is diſengaged, at the ſame time that a ſmall portion of unaltered camphor ſublimes. This operation is repeated three times upon the ſame camphor. The camphoric acid is cryſtallized by the cooling of the fluid which remains in the retort. It is purified by ſolution in boiling water and cooling. The acid thus obtained does not amount to quite half the weight of the camphor. This acid, which appears to cryſtallize in acute octahedrons, has a ſlightly ſour but conſiderably bitter taſte. It reddens turnſol, and effloreſces in the air. Cold water diſſolves ſcarcely more than one-three hundredth of its weight; boiling water, on the contrary, diſſolves nearly one-twelfth. Upon ignited charcoal it emits an acrid aromatic denſe fume, and is entirely diſſipated. It melts and ſublimes by a regulated heat. When paſſed through an ignited tube with oxigen gas, it remains without alteration. Nevertheleſs, by diſtillation in a retort, Citizen Lagrange had expectation of decompoſing it, as it loſt its acid nature, its ſolubility in water, and had acquired an aromatic odour. This acid is alſo ſoluble in oils. Its combinations with the earths, the alkalis, and the metals, are different from thoſe of all the known acids. It does not precipitate lime-water; the camphorate of pot-aſh, and ſeveral other camphorates, are very cryſtallizable. The camphoric acid precipitates various metallic ſolutions, particularly the ſulphate, and the muriate of iron.

15. Camphor is not changed, nor ſoluble in the alkalis. No ſalt acts upon it, except the ſuper-oxigenated muriate of pot-aſh, which burns and deſtroys it by a blow or by preſſure. It has no attraction for the metallic acids, nor for the ſolutions of the metals. It mixes, and is ſuſpended in water by the medium of ſugar, or the mucilages. Fixed and volatile oils diſſolve it, and nature frequently preſents this ſolution, as I have already ſhown.

16. Though the accurate analyſis of camphor and its chemical properties are yet far from being known with the accuracy that may be wiſhed, thoſe which I have here pointed out will ſufficiently diſtinguiſh this body from volatile oils, and to juſtify us in admitting it as one of the immediate materials of vegetables, which deſerves to be carefully ſtudied. Its property of forming a peculiar acid by the action of fire, or of the nitric acid, is ſufficiently characteriſtic. It was lately conſidered as a volatile oil, more carbonated than thoſe which are particularly diſtinguiſhed by that denomination.

E. *Species.*

17. If there be truly no more than one ſpecies of camphor always of the ſame nature, whatever may be the vegetable from which it was obtained;

obtained, it is nevertheleſs true, that, together with the reſemblance of the greateſt number of its diſtinctive properties in the different plants which contain it, it alſo preſents certain differences, particularly that of an odour reſembling the vegetable form from which it was extracted. Under this point of view, we may therefore admit as many ſpecies as there are plants hitherto diſcovered which afford it, though the qualification of ſpecies may be really too marked a term to diſtinguiſh ſimple varieties. Thus, beſides the true camphor obtained from the camphor-bearing laurel, we may admit the camphor of lavender, of ſage, of roſemary, of marjoram, of aniſeed, of ſaſſafras, &c. This diſtinction, however, muſt become either more accurate or uſeleſs at the period when chemiſts, after comparing theſe different varieties of camphor, ſhall have diſcovered characters peculiar to each, or have confirmed their perfect identity.

F. *Uſes.*

18. Camphor is one of the moſt powerful remedies which medicine poſſeſſes. As a topical remedy it calms inflammations, ſtops gangrene, and diſſolves various tumours. Internally, it is anti-ſpaſmodic and antiſeptic. It is very ſucceſsfully employed in contagious diſorders, in intermittent or putrid fevers, as well as thoſe of a malignant and nervous deſcription. It is particularly active in affections of the urinary paſſages,

ſages, and ſtops the pernicious effects of cantharides on thoſe organs. It is preſcribed in the doſe of ſeveral grains in pills, boluſſes, electuaries, mixtures, in which it is diffuſed by means of the yolk of egg, mucilages, and ſugar. Its ſolution in alcohol is much employed internally. It enters into a great number of pharmaceutic preparations.

19. It is particularly uſed in embalming. It powerfully preſerves putreſcent ſubſtances, ſtops the ſeptic alteration, as is proved by all the experiments of the moderns upon putrefaction and antiſeptics. It is much employed to defend furs, feathers, and animal ſubſtances in general, particularly preparations of natural hiſtory from alteration. It operates in this reſpect, by preventing the approach of inſects, and accordingly it is much uſed in cabinets and collections of animal matters from America and India.

20. Camphor is alſo of uſe in ſome of the arts as a combuſtible ſubſtance. It is an ingredient in fire-works, and is ſaid to have been a part in the famous compoſition named the *Greek fire.* Moſt of the incendiary preparations, intended to produce their effect in water, likewiſe contain a more or leſs conſiderable quantity.

Article XV.

Concerning the Twelfth of the immediate Materials of Vegetables, namely, the Reſins.

A. *Situation.*

1. UNDER the article of volatile oils we have ſeen, that when expoſed to the air, they become condenſed and converted into reſin. It ſeems, therefore, that there is no other difference between theſe ſubſtances but the condenſation here mentioned, and that we may define reſins by the name of condenſed volatile oils. But this ſimple expoſition gives us but a very imperfect notion of reſinification, that is to ſay, the converſion of thoſe oils into reſin. It is very evident, in fact, that the reſins owe their origin entirely to the volatile oils, that they are always firſt in this ſtate; but in this ſimple expreſſion of the fact, we do not ſee the manner of operation or the cauſe which produces the effect, or the true reſult it affords. It is neceſſary to examine the phenomenon more narrowly, in order to aſcertain what reſinification conſiſts in, and to determine what happens during the converſion of the volatile oils into reſin.

2. Mr. Prouſt, in his Diſſertation on Camphor, obſerves, that moſt of the volatile oils when expoſed

poſed to the air, are ſeparated into two ſubſtances, one of which is acid, and the other reſinous. It is probable that the former is analogous to the Benzoic or camphoric acid. With regard to the converſion of a portion of volatile oil into reſin, this chemiſt attributes it to the abſorption of oxigen, as well as acidification; and he explains theſe ſimultaneous changes by admitting two different ſubſtances in the oils, one a ſpecies of acidifiable radical, and the other reſinifiable radical. Though this ingenious theory may appear to ſatisfy the phenomena, or rather the reſults obtained by the expoſure of the volatile oils to the air, it is far from being yet confirmed by experience.

3. Experience indeed proves, that by expoſing the volatile oils to the contact of oxigen gas, as well as by treating them with bodies which can eaſily communicate this principle, they in fact become condenſed, and approach to the nature of reſins, at the ſame time that they are partly acidified; but it does not exactly prove that theſe changes are owing merely to abſorption of oxigen. On the contrary, we find by expoſure of theſe oils to the air, that they are more diſpoſed, as I have obſerved, to loſe or part with a portion of their hidrogen, than in truth to abſorb oxigen. They gradually form water, which is collected even on their ſurface, or which lines the inſide of the glaſs veſſels in which this experiment is made with very viſible drops; and as theſe oils become at

the ſame time more denſe, we may attribute their reſinification much more to the loſs of their hidrogen, than to the abſorption of oxigen. They alſo at the ſame time ſuffer a portion of their carbon to exhale; for the air in which they have remained for a long time becomes charged with a greater or leſs quantity of carbonic acid.

4. We may in the mean time, and this is the moſt juſtifiable conduct to be purſued, until inquiries ſhall have been carried further on this object;—we may admit the contemporaneous action of the air upon the volatile oils, the loſs of hidrogen, and its abſorption of oxigen from them, admitting, at the ſame time, that the latter of theſe phenomena is much more evident than the communication of oxigen. We may define reſinification to be a ſpecies of oxidation of volatile oil, owing to the diſſipation of part of their hidrogen, and the abſorption of a ſmall portion of oxigen. Hence we may conceive why few oils paſs to the ſtate of reſin, in what manner reſinous matter is formed in vegetables, why this formation takes place at their ſurface, where the volatile oils flow out, and alſo in their barks or firſt ligneous ſtrata.

5. From this theory, which is defective only in point of preciſion, we may conceive, that reſin is to volatile oil the ſame thing which vegetable butter or wax is to fixed oil. Nothing more will remain but to determine the proportion which exiſts between the ſame volatile oil and

camphor; whence it happens that certain ſpecies of this genus contain camphor, that others are more diſpoſed to form reſin or benzoic acid, if it be true that each of theſe three bodies, camphor, reſin, and benzoic acid, be not a peculiar modification of volatile oil, and each of them be not capable of paſſing to either of the ſtates reſpectively by a determinate variation of its principles. Whatever may be the caſe, it is eaſy to conceive that reſin will be found in thoſe ſituations where volatile oil is found, and that every thing, which is obſervable with reſpect to the oil, is applicable alſo to reſin as far as relates to its ſituation.

B. *Extraction.*

6. Resin frequently flows from the external parts of vegetables in a ſoft and partly liquid ſtate, as will be ſeen in moſt of the ſpecies of this genus. The efflux is ſometimes accelerated by boring holes, or making inciſions in the trees which are capable of affording it, as is done with regard to all thoſe denominated reſinous, ſuch as the pine, the fir, the larch, &c. It then flows out in the form of a thick, viſcid, tranſparent fluid, often with little ſmell, which is collected in a more or leſs conſiderable quantity.

7. Frequently alſo the reſin remains in the vegetable organs where it was formed; acquires a ſolidity more or leſs conſiderable; becomes dry

and brittle; is depoſited in plates or thin leaves, or varniſh—like ſtrata, which cannot be extracted by preſſure, or any other mechanical means. Neverthele ſs it ſometimes happens, that after having obſerved in the texture of ſolid vegetable ſubſtances, diſtinguiſhable by its brilliancy, its vitreous texture, and its brittle property, it is found to ſeparate in the form of a powder more or leſs coloured, becoming fatty and unctuous by preſſure and pulverization, and not to be confounded with the woody powder or fibrous lamellated fecula obtained by raſping or pounding ſolid vegetable ſubſtances. This fact is obſervable in the operations of pharmacy, and of perfumery; but it is not ſufficient for chemiſts; and whatever precautions they may take, they cannot by this means procure a quantity of reſin ſufficiently abundant for their experiments, or ſufficiently pure to be uſed in their reſearches.

8. When the reſin exiſts dry in very ſmall fragments or thin plates, in dry vegetable matters, as here pointed out, there are two methods of extracting and ſeparating this reſin from other vegetable ſubſtances with which it is mixed. The one, which is not commonly employed with this view, takes place in the decoctions to which various ſolid vegetable bodies, ſuch as the roots, the wood, the bark, the fruits, &c. are ſubjected. The heat of boiling water ſoftens and melts this reſin, which ſeparates, and is often collected in the form of oily,

yellow, red, or brown drops at the ſurface of the water, which afterwards becomes more denſe and hard, and falls to the bottom of the liquid; but in this caſe it mixes, and is confounded with the extractive matter, which, as we have ſeen, becomes inſoluble and ſolid by the action of the atmoſpheric oxigen. The other proceſs, which is the only means practiſed in chemiſtry to extract the dry reſin from vegetable bodies which contain it, conſiſts in applying an appropriate ſolvent. Alcohol is employed for this uſe; it is left to macerate for a certain time on vegetable ſubſtances, from which the reſin is to be extracted, and which have been previouſly ſtamped, pounded, or cut into ſmall pieces: it is ſometimes boiled, and afterwards evaporated to dryneſs, ſo that the reſin remains alone and dry; nevertheleſs it is mixed with ſome other immediate principle of vegetables. It is ſeparated by precipitation with water.

C. *Phyſical Properties.*

9. **Resin** is either ſoft, viſcid, liquid, or dry, brittle, of a glaſſy appearance; fine-grained, and more or leſs beautifully tranſparent. Its white, or greeniſh yellow colour, when liquid, is extremely varied in the different ſpecies when dry and brittle; moſt commonly it is of a lemon or amber-yellow colour, of more or leſs bright red, or red-brown. It is found of a

red-brown, green, or deep red colour; but in this caſe it is always opaque. It is eaſily reducible into powder, and its powder is unctuous, and ſticks together by percuſſion.

10. All the reſins are rather heavier than water. Their ſpecific gravity varies from 10,452 to 12,289, water being 10,000. Moſt of them have no taſte, or a very weak taſte, even when maſticated for ſome time. Their ſmell is almoſt always weak, and does not become perceptible but by long grinding, or an elevated temperature. Reſins have almoſt conſtantly a decided character of acidity.

11. The reſins, expoſed to the weak action of caloric, ſoften and melt like wax without alteration. Each requires a particular temperature for its fuſion. By cooling, they reſume the concrete ſtate. It is well known that reſins inſulate and intercept the paſſage of the electric fluid, and that they are themſelves electric by friction.

D. *Chemical Properties.*

12. RESIN, treated by fire in cloſe veſſels, affords volatile oil in quantity greater as the reſin is ſofter. Thus it is that turpentine and all the trees of the genus *pinous*, afford very great proportions of volatile or eſſential oil. The reſidue is a reſinous matter much drier than before, and frequently of a brown or black colour. If the fire be urged ſtill more, the product

is water, an acid liquor, carbonated hidrogen gas, carbonic acid gas, and there remains a voluminous charcoal more abundant in its bulk than from the volatile oils.

13. Reſin, heated with contact of the air, takes fire after having melted and boiled up; its flame is ſtrong and large, and its ſmoke conſiderable; it affords a very abundant ſoot, which is condenſed and collected in ſome manufactories in cones of plate-iron, under the name of lamp-black. Much water is alſo formed in this combuſtion.

14. Reſin unites by fuſion with ſulphur; more difficultly with phoſphorus, and not at all with the metals. There is no union between reſin and the metallic oxides, in which reſpect theſe bodies differ much from fixed oils. There is no action between reſin and water. When reſin is inflamed, it decompoſes water poured upon it, and produces an exploſion, which however is leſs violent than that occaſioned by the fixed oils.

15. Neither the acids nor the alkalis exerciſe any action upon reſin, by inflaming, burning, or converting it into ſoap. This want of effect reſembles the property of oily oxides, and favours the opinion of thoſe who think that reſin owes its ſtate to the abſorption of oxigen. The ſame is the caſe with regard to the oxigenated muriatic acid, the oxides, and the metallic ſolutions.

16. It is almoſt ſuperfluous to obſerve in this place, that liquid reſins which contain the greateſt quantity of volatile oil, are more alterable in general than the dry and brittle reſins; it may eaſily be conceived that they muſt participitate in the characters and properties of the oils they contain.

E. *Species.*

17. The number of the ſpecies of reſin is very conſiderable. There is ſcarce a plant or vegetable which does not contain it, and from which it may not be extracted by ſome chemical proceſs. An enumeration of the ſpecies would therefore be impoſſible, illuſive, or unneceſſary, if we did not confine ourſelves particularly to thoſe which are moſt uſeful, the moſt eaſily extracted, and which nature itſelf offers to man by their ſpontaneous flux, which are the moſt abundant, and at the ſame time moſt frequently employed in the arts. I particularly reckon the thirteen following reſins, obſerving, that ſome of them are known in commerce by the name of balſams, on account of their liquid ſtate only, and not from their nature, becauſe they are not true balſams, as I ſhall ſhow, when I treat thoſe ſubſtances in one of the following articles.

A. Balſam of Mecca, from Judea, Egypt, and Grand Cairo. This is a liquid, white, bitter

ter reſin, of a very ſtrong ſmell of lemon, which flows from the tree called *amyris opobalſamum*, found by Forſkahls in Arabia Felix, and placed by Linnæus in the claſs of *octandria monogynia.* This liquid reſin affords much volatile oil by diſtillation; it becomes thick by long contact of the air, and forms a ſolid cruſt at its ſurface. It is uſed in medicine as a vulnerary, incorporated with ſugar, the yolk of egg, &c.

B. Balſam of *Copahu*, another ſpecies of brown or yellow liquid reſin, which flows from the tree called *Copaiba*, named by Linnæus *Copaiſera*, and placed by that botaniſt in the claſs of decandria monogynia: the common ſpecies, as well as that of the balſam of Tolu, a true balſamic juice of which I ſhall hereafter ſpeak, is a mixture of true reſin of copahu and turpentine, according to Cartheuſer. It is employed in medicine in ulcers of the lungs, and the bladder, like the preceding.

C. Chio turpentine flows from the turpentine tree, which affords the piſtachia nut, terebinthus piſtachia of Linnæus; it is of a white or blueiſh-yellow colour. It affords a very pure volatile oil on the water-bath. That which it affords to a naked fire is leſs fluid. The turpentine is afterwards yellower; if it be diſtilled with water, it becomes white and ſilky, and is denominated boiled turpentine. This turpentine, the only ſpecies which ought to bear the preſent name, is ſcarce and little uſed.

D. Venice turpentine, or reſin of the larch, is commonly employed in medicine. It is uſed in its natural ſtate, or combined with fixed alkali. This combination is the true ſoap of Starkey, or the ſaponule of turpentine. In order to prepare it, the Paris diſpenſatory preſcribes to pour on two parts of nitre fixed by the tartar and ſtill hot, one part of the volatile oil of turpentine; to agitate the mixture with an ivory ſpatula, and to cover the veſſel with paper; the oil is gradually to be added until the whole forms a white maſs. As this proceſs laſts ſeveral months, chemiſts have endeavoured to diſcover the means of making the ſoap in a more expeditious manner. Rouelle, by triturating drop by drop, the alkali with the ſoap, and adding a ſmall quantity of water towards the end prepared in three hours a conſiderable quantity of this ſaponule. Citizen Baumé adviſes levigation upon a ſtone of one part of alkali of tartar, dried ſo as to enter into fuſion, and gradually to add two or three times its weight of volatile oil of turpentine. When the mixture has acquired the conſiſtence of a ſoft opiate, it is put into a glaſs bottle covered with a paper, and expoſed in a humid ſituation. In fifteen days, the deliqueſcent alkali forms a particular ſtratum of the fluid at the bottom of the veſſel; the ſoap is in the middle, and a portion of the oil which has acquired a red colour, floats at the top. Citizen Baumé thinks that the alkali unites only with that portion of the oil which is in the ſtate of reſin. Legendre extends this notion by propoſing to ſaturate fixed alkali without heat in ſolution with thickened oil of turpentine, or turpentine itſelf.

This ſaponule has a certain degree of ſolidity, which gradually becomes more conſiderable; it forms cryſtals which have been conſidered as a combination of the acid of the oil with the vegetable fixed alkali, which, according to the academicians of Dijon, are only pot-aſh ſaturated with carbonic acid, and cryſtallized. As this ſaponule is very difficult to make, and very changeable, Macquer thinks that when it is deſirable to unite the properties of volatile oil with that of ſoap, it is better to incorporate with the white medicinal ſoap ſome drops of the volatile oil appropriated to the indication intended to be anſwered. Ammonia, triturated with turpentine, forms a ſaponaceous ſolid compound, which is very ſoluble in water, and renders it milky and frothy.

E. The reſin of the fir is named Straſburg turpentine. It is collected by piercing the veſſicles of the bark of the tree which is very abundant in the mountains of Switzerland. It may be uſed for the ſame purpoſes as the preceding.

F. Pitch is the reſinous juice of a kind of fir named Picea. It is extracted by inciſions made in the bark of the tree; it is melted by a gentle heat, ſtrained through a ſack, and received in caſks, where it conſtitutes Burgundy pitch or white pitch: when mixed with lamp-black, it is black pitch. By long fuſion it becomes dry, brown, and forms colophany. The coarſer parts are burned in an oven, which has a chimney terminating in a ſmall receptacle ending in an iron pipe. In this laſt the ſmoke becomes condenſed, and forms a fine ſoot called lamp-black.

G. Galipot is the reſin of the pine, which affords ſweet kernels. This tree is tapped towards the lower part of the trunk, and the reſin flows into veſſels placed to receive it. Other inciſions are made when the former ceaſe to exſude. When it flows out in a fluid ſtate, it is called *galipot;* that which dries on the tree in yellowiſh maſſes is called *barras.* Thoſe juices are liquified in boilers, and ſtrained through ſtraw mats. This maſs, caſt into pieces or loaves, in excavations made in the ſand, is called in French *arcançon*, or *brai ſec.* If water be interpoſed, the matter becomes white, and forms reſin or pitch reſin. The Provincials diſtil the galipot in the large way, and obtain an oil which they call *huile de raze.* Tar is prepared with the trunks and roots of the pine of which it is the empyreumatic oil. The branches of the tree are heaped up, covered with turf, and ſet on fire. The oil diſengaged by the heat not being capable of exhaling through the turf, is precipitated into a veſſel by means of a gutter, whence it is laded out, and ſold under the name of tar.

H. Tacamahaca, gum elemi, gum anime, are little in uſe. The tree, which affords the firſt, is not known; the elemi comes from a ſpecies of amyris; the oriental gum anime, or copal, of which the origin is unknown; the occidental anime, or courbaril, which flows from the hymenæa, a tree of South America, are employed in varniſhes.

I. Maſtic has the form of white tears of a faint ſmell; it flows from the turpentine tree and the lentiſc. It is uſed as an aſtringent and aromatic, and is an ingredient in drying varniſhes.

K. Sandarac has the form of white tears more tranſparent than thoſe of maſtic. It is obtained from the juniper between the bark and the wood; it is alſo called varniſh by ſome, becauſe it is much uſed in thoſe preparations. It is moſt generally known in its application upon paper, where eraſures have been made in order to prevent the ink from ſpreading.

L. The reſin of gayac, or gum gayac, which is greeniſh, is employed againſt the gout; it flows from the gayac by inciſions. Many chemiſts conſider it as a gum reſin.

M. Ladanum, or the reſin of a ſpecies of ciſtus in the iſland of Candia, is of a blackiſh colour. The peaſants collect it with a rake, to which are ſuſpended a number of ſtraps of leather, which they paſs in contact with the trees; they form cylindric portions, which are called *ladanum in tortis.* It is adulterated by much black ſand. It is employed as an aſtringent, and is the moſt impure and moſt ponderous of the reſins.

N. Dragon's blood is a red juice obtained from *Dracæna draco,* and many other vegetables. It has the form of flattened or rounded maſſes, or of ſmall ſpheroides, or olives covered with leaves of reeds and tied together. It is uſed in medicine as an aſtringent.

18. It is not unuſual to preſerve in collections, ſometimes under the name of gums, a continued ſeries of different reſinous juices of Africa, America, and India, which are not uſed in Europe, and of which it is unneceſſary to ſpeak in this place. They are known to be reſins by their fuſibility, their inflammability, their inſolubility in water, and their ſolubility in alcohol.

F. *Uſes.*

19. In the rapid enumeration here preſented, reſpecting the moſt common ſpecies of reſins, we have ſeen that theſe juices, moſt of which are particularly conſecrated to medical uſe, are very far from poſſeſſing all the virtues commonly attributed to them. Their external application is the moſt beneficial and the beſt known with regard to its antiſeptic effects.

20. Many of them are more or leſs uſeful in the arts as combuſtibles. Some nations uſe it

for the purpoſes of combuſtions or illuminations, and they are employed in embalming and perfuming. The art of painting derives great advantage from them; they are the baſis of varniſhes, particularly that which is named Chineſe varniſh. They afford oils of great value for painting and for ſhip-building; pitch, tar, and lamp-black, are the products of theſe ſubſtances; and in a word, there are few materials which are more eminently uſeful.

ARTICLE XVI.

Concerning the Thirteenth of the immediate Materials of Vegetables, namely Gum Reſins.

A. *Situation.*

1. THE name of gum reſin is given to certain inflammable juices partly ſoluble in water, partly in alcohol, which are thought to be natural combinations of reſins, and mucilaginous extractive matters.

2. Theſe juices are contained in the proper veſſels of a great number of vegetables, none of their parts being deprived of them; or rather they are found in the roots, the ſtems, the leaves, the flowers, and the fruits of many plants.

3. We muſt nevertheleſs obſerve, that theſe two laſt kinds of organs, the flowers and the

fruits, are moſt commonly without the ſubſtance, as alſo are the ſeeds, and that it is moſt particularly found in the roots, the ſtems, and the leaves. Theſe three claſſes of vegetable parts are in fact thoſe in which Grew, Malpighi, Bonnet, and Duhamel, found the greateſt abundance of proper veſſels frequently placed in aſſemblages beneath the bark, or in the firſt ligneous ſtrata.

B. *Extraction.*

4. There is this very ſenſible difference between reſins and gum reſins, that the latter being included in the proper veſſels, are never extruded from the plants; whereas the reſinous juices flow ſpontaneouſly on the ſurface of vegetables, where they dry and become condenſed in the form of brittle tears. The gum reſinous juices, on the contrary, being concealed in the inner parts of plants never flow out, and art alone can extract them from the channels in which they are contained.

5. When the texture of a recent vegetable is broken in thoſe parts which contain gum-reſinous juices, they iſſue forth in white, yellow, or variouſly-coloured drops always opaque or milky, reſembling emulſive fluids. If the parts charged with theſe juices be preſſed, or if, after having collected a ſufficient quantity by the ſlight efflux which follows their inciſion, by receiving the ſame from a large quantity of ve-

getable matter, at the ſame time this juice may be condenſed by the rays of the ſun, and the elevated temperature of a hot climate, ſuch as favours the vegetation of this genus of plants. In this manner the gum-reſins are obtained.

6. Such is the general proceſs which is followed to procure them. The vegetables which contain them are cut or notched when full of juice; the juices are collected by leaving the vegetables to emit the opaque fluid they contain; this is expoſed in a thin ſtratum to the rays of the ſun in Africa, America, or the Eaſt-Indies; where it condenſes, evaporates, and becomes thick, and at laſt dry. It is in this complete ſtate that the gum-reſins are met with in the market.

C. *Phyſical Properties.*

7. The gum-reſins, extracted and prepared by the means here pointed out, are ſolid brittle bodies, almoſt always opaque, in irregular tears or fragments often adhering to each other, or by means of a paſte which connects them together. Moſt of them have a conſiderable odour uſually of a fetid or garlic ſmell, with an acrid diſagreeable, bitter, and nauſeous taſte.

8. Their colour in the different ſpecies is ſingularly varied; but a yellow ruſty colour is generally predominant. They are not in general proper electrics, like the reſins, nor do they equally well intercept the courſe of the electric

fluid.

fluid. They are not fuſible in the ſame manner by heat, and they become changed inſtead of flowing like them by the action of heat.

D. *Chemical Properties.*

9. THOUGH few chemical experiments have yet been made upon theſe ſubſtances, except certain very incomplete analyſes, and no truly connected reſearches have been made upon the gum reſins, there nevertheleſs exiſt in the midſt of the aſſays of pharmaceutic operations upon theſe bodies ſome general phenomena which may ſerve as characters to diſtinguiſh them from the other immediate materials of vegetables, and which may be conſidered as properties belonging to the whole genus: the following may be conſidered as generic qualities.

10. All gum reſins burn, dry, ſwell and emit fetid vapours without taking fire: at firſt when heated upon burning coals they afford by diſtillation, beſides the volatile oils, ammonia combined with an acid, and leave a voluminous ſaline charcoal. They alſo afford much carbonic acid gas by diſtillation.

11. They all unite with water by trituration; and form a kind of emulſion, or milky turbid liquor, which by the action of fire or of the air depoſits a portion of reſin, and retains in ſolution a ſubſtance rather extractive than gummy or mucilaginous. Their ſolution in water is frequently acid. The concentrated ſulphuric acid

decompoſes and carbonates them. The nitric acid converts them partly into oxalic acid. The weak acids diſſolve them, and the acetous acid has long been conſidered as their ſpecific ſolvent.

12. The alkalis have not the ſame inactivity with regard to the entire gum reſins as with reſpect to the true reſins; and when in pharmacy theſe ſubſtances are uſed to diſſolve, as it is pretended, the reſin by boiling woods or barks in water---it is not the reſinous principle which the alkalis thus abundantly take up, but the portion of extractive matter oxigenated and become inſoluble, as I have elſewhere ſhown; that is to ſay, a true gum-reſinous matter, for this extractive matter being united to the alkali in that caſe, carries with it a ſmall portion of reſin. The ſame obſervation is applicable to magneſia, when employed to the ſame purpoſe.

13. Among the immediate materials of vegetables, which have ſome action upon gum-reſin, we muſt reckon the mucus, ſugar, and non-oxigenated extractive matter, which render it either ſoluble in water, or miſcible in that liquid, as all the pharmaceutical operations prove which are uſed for the medical adminiſtration of this ſubſtance.

E. *Species.*

14. The gum-reſinous juices are extremely numerous in plants, and may be diſtinguiſhed

into an immenſe variety of ſpecies; but we do not in this place treat upon more than thoſe which are moſt generally known and employed either in medicine, where they are conſiderably uſed, or in the arts.

A. Olibanum or *incenſe* has the form of yellow tranſparent tears, of a ſtrong and diſagreeable odour when burned. It flows on the banks of the red ſea, from a kind of juniper or *thurifera.* By heat it affords volatile oil, an acid liquor, and leaves charcoal, owing to the extractive part it contains. In medicine it is uſed for attenuant fumigations. Notwithſtanding its name, this is not the gum-reſinous body which is burned as incenſe, for its odour is acrid and fetid; we ſhall ſee that the balſams are employed for that purpoſe.

B. Galbanum is a fatty juice of a brown-yellow, and nauſeous odour. It flows in Syria, in Arabia, and at the Cape of Good Hope, from inciſions made in a ferulaceous plant called by Linnæus, *Bubon galbanum.* Its ſmell is manifeſtly that of garlic. When diſtilled by naked fire it affords a blue volatile oil, which becomes red by keeping, together with an acid liquor and an heavy empyreumatic oil. It is a very good attenuant, and a powerful antiſpaſmodic, and is an ingredient in many plaſters and unguents.

C. Scammony is of a blackiſh-grey colour, of a ſtrong and nauſeous ſmell when pounded or heated, and of a bitter and very acrid taſte. We diſtinguiſh that of Aleppo, which is the pureſt, in contorted fragments, covered with a grey homogeneous powder; and that of Smyrna, which is heavy, black, and mixed with foreign ſubſtances. It is extracted from the Convolvulus of Linnæus. The root of that plant cut and expreſſed on the place or in the earth, affords a pale juice, which is collected in a cavity formed in the lower part of the root, and which becomes black as it dries. Scammony contains a various quantity of extract or reſin, according to the different ſamples: in conſequence of which it produces very different effects in different patients. It is uſed as a purgative in the doſe of two or three decigrams to ſix or eight; when mixed with a mild extract, ſuch as that of liquorice, it forms the common diagrydium; and for this purpoſe alſo the juice of quinces is uſed. It is commonly adminiſtered by trituration, with ſugar and ſweet almonds, in the ſtate of an emulſion. We are not yet in poſſeſſion of a good analyſis of this gum-reſin, which is much employed in medicine, as well as moſt of the gum-reſinous juices.

D. Gum guttæ or gamboge has the form of cylindrical maſſes, hollow in the middle, fluted without, of an orange-yellow colour without ſmell, but of a very acrid and corroſive taſte. It comes from Siam, China, and the iſle of Ceylon. It is extracted from a large tree which is little known, but denominated Coddam in the country, and Cambogia by Linnæus, who placed it in the polyandria monogynia. It is diffuſible in water, in which it forms a kind of yellowiſh emulſion; its acrid property appears to be owing much more to the extract than the reſin which it contains; it is ſtrongly purgative in the doſe of from two decigrams to four or five: It muſt not be employed internally without the greateſt caution: the alkalis greatly diminiſh its acridneſs. Painters uſe it much as a fine golden-yellow pigment; it mixes very well with fixed and volatile oils.

E. Euphorbium is in yellow tears, worm-eaten or corroded, in ſmall contorted cylinders, full of holes, of a cauſtic taſte, and without ſmell. It flows from inciſions in the euphorbium, in Lybia and Mauritania; it is collected round the thorns of this plant, upon which it becomes condenſed and formed. It contains a very acrid reſin, and is ſo ſtrongly purgative, that it is reckoned among the poiſons: It is ſeldom employed but externally in mortifications, of which it ſtops the progreſs, or as a detergent in ulcers.

F. Aſſa fœtida is ſometimes in yellowiſh tears, and moſt frequently in maſſes formed of various parts agglutinated together, of a ruſty colour, ſhaded with different degrees of yellow. Its garlic ſmell is extremely fetid, and its taſte bitter, nauſeous, and diſagreeable, is ſufficiently diſtinguiſhed among all the other gum reſins. It is extracted from the root of a kind of ferula, which grows in Perſia, in the province of Chorafan, and which Linnæus has denominated aſſa fœtida. The root of this plant is fleſhy and ſucculent; it affords by preſſure a white juice of an abominable ſmell, which the Indians uſe as a condiment which they call food of the Gods, a very ſingular contraſt with the name of Stercus Diaboli, which is given to it in Europe. When diluted in water, aſſa fœtida oppoſed by this name to that of aſſa dulcis, formerly given to benzoin, forms a kind of milk or turbid liquor of a ruddy white, and very expanſible odour, which infects a great ſpace. It is internally uſed as a powerful antiſpaſmodic, and applied externally as a diſcutient.

G. Opoponax is a gum-reſinous juice in irregular plates, of a dark or ruſty yellow, ſtrong garlic fetid ſmell, with an acrid, bitter, and very diſagreeable taſte. It is extracted from the paſtinaca opoponax of Linnæus, in Perſia, in Turkey, and even in ſome hot countries of France and Italy.

This juice is ſuppoſed to contain equal parts of extractive and of reſinous matter. It is uſed in medicine as an attenuant, and enters into the compoſition of ſeveral plaſters.

H. Bdellium is a browniſh juice, ſuppoſed to be very analogous to galbanum. Its origin is not known. Enlightened botaniſts conſider it to be very different from that of the ancients, which was highly eſteemed.

It is thought to be compoſed of nearly equal parts of extract and of reſin. It has leſs taſte and ſmell than galbanum, and is manifeſtly inferior to it in virtue. It is at preſent ſcarcely at all employed in medicine, though it ſtill conſtitutes an ingredient in ſome pharmaceutic compoſitions.

I. Sagapenum is gum-reſinous juice in white, yellowiſh, or ruſty tears, of a diſagreeable and inſupportable ſmell when thrown on lighted coals. Its taſte is acrid, bitter and repulſive. It comes from Egypt, Perſia, and India; but the tree which furniſhes it is unknown.

In general this vegetable juice reſembles in its properties gum ammoniacum, galbanum, opoponax, &c. All the gum reſins having a garlic flavor appear to be proper juices of umbelliferous plants. Sagapenum is no longer particularly uſed.

K. Sarcocolla, a reſinous gummy juice, ſo denominated becauſe the property of cloſing wounds was formerly attributed to it, is known by its figure in ſmall grains reſembling thoſe of millet, of a white, yellow, or red colour. It has no ſmell, and its taſte is bitter and nauſeous. It comes from Perſia and Arabia, from an unknown vegetable: it contains more extract than reſinous matter. Its ſuppoſed virtues are no longer credited, and it is uſed only in a few compoſitions.

L. Myrrh is a concrete juice in reddiſh brilliant tears, frequently covered with a ruſty coloured powder, of a ſtrong but agreeable ſmell, with a bitter and rather aſtringent taſte, and preſent in their fracture, white lines of the form of a nail. Some of theſe tears are entirely gummy, inſipid and inſoluble in water. It has the appearance of a mixture. Myrrh comes from Egypt, and particularly from Arabia, the ancient country of the Troglodites. The plant which affords it is unknown: it contains much more extractive and mucilaginous matter than reſin. When it is pulverized and held for ſome time in the mouth, it ſoftens and becomes white and ductile like wax. It is uſed in medicine as a very good ſtomachic, antiſpaſmodic and ſtrengthener. Cartheuſer recommends it to literary men who have a delicate ſtomach, to chew and ſwallow it diluted in the ſaliva. It is uſed in ſurgery to cleanſe ulcers, and to ſtop the progreſs of caries. It is employed in powder or diſſolved in alcohol.

M. Gum ammoniac is ſometimes in ſingle tears, white within, and yellow externally, and often in maſſes reſembling thoſe of benzoin, formed of white tears, connected by a more coloured and adheſive juice. Their white colour and fetid ſmell eaſily ſerve to diſtinguiſh them from benzoin, which they conſiderably reſemble. It is ſuſpected that this gum-reſin which comes to us from Africa, is obtained from an umbelliferous plant, on account of the ſeeds which are mixed with it; but we do not know the plant which produces it, the manner of its growth, nor the mode of its preparation.

The phenomena of the ſolution of this ſubſtance by water and by alcohol, and particularly its inflammability ſhow that it reſembles the reſino-extracts of Rouelle.

Gum ammoniac is uſed in medicine as a very good attenuant in obſtinate obſtructions. It is given in the doſe of a few grains in pills, or in emulſion. It likewiſe enters into the compoſition of a number of attenuant plaſters, as well as the other gums before deſcribed.

F. *Uſes.*

15. The foregoing account of the principal ſpecies of gum-reſins proves that their uſe is particularly applicable to medicine, and ſcarcely at all to the arts, if we except the ſlight employ which ſome of them have as pigments.

16. It is very remarkable that the gum-reſins are either purgative, draſtic, and even almoſt cauſtic, or elſe antipaſmodic; ſo that they may be divided into two genera with regard to their medicinal properties.

Article XVII.

Concerning the Fourteenth of the immediate Materials of Vegetables; of Caoutchouc, or Elaſtic Reſin.

A. *Situation.*

1. CAOUTCHOUC, or elaſtic reſin, very improperly called elaſtic gum in the arts, is one

of thoſe vegetable matters of which it has been difficult, if not impoſſible, to determine exactly the nature, ſo far as to compare it with the other immediate materials, and to place it in the claſs either of reſins or concrete fixed oils, which it reſembles. By comparing all its properties with thoſe combuſtible matters, we ſoon diſcover that it is a particular principle really different from every one of them, and that it is only remotely analogous to them. It is neither a fixed oil, nor a reſin, nor a gum-reſin, but a peculiar ſubſtance itſelf.

2. I place it as one of the immediate materials of vegetables, becauſe it appears that we can extract caoutchouc from various American trees, and that it is not peculiar to the juice of the hevæa of Aublet. Some botaniſts, particularly travellers, aſſure us that elaſtic reſin is obtained from various trees of thoſe countries, and that it is prepared by condenſing and evaporating the mixture of a number of thoſe juices.

3. It is in an order of proper veſſels that this white juice, reſembling an emulſion and to that which the gum-reſins afford, is contained. It appears to exiſt particularly under the bark of the hevæa. Some have apprehended that ſeveral lacteſcent plants of our temperate climates, particularly ſome ſpecies of Euphorbia, might afford a ſubſtance analogous to caoutchouc; and though the firſt aſſays have not yet produced an authenticated ſucceſs, this view is far from being improbable.

B. *Extraction.*

4. In America, particularly in Guiana, inciſions are made acroſs the bark of the hevæa to its ligneous part. The white juice which flows out is received in a veſſel. As the only intention for which it is collected is to fabricate veſſels, or a kind of pear-ſhaped bottles, this juice is applied in layers upon moulds of dry clay: each layer is dried in the ſun or by the fire, the ſmoke of which colours them of a deep fawn or brown colour. The ſucceſſive application of theſe ſtrata is continued until the veſſels are rendered as thick and as ſtrong as may be deſired. The natives of the country employed in this labour terminate it by uſually making deſigns or various engravings with points of iron. When the juice has become thick, concrete, and ſolid, the brittle earth which formed the mould is cruſhed, and ſhaken out in ſmall fragments through the aperture of the veſſel.

5. In this operation, the juice of the hevæa becomes concrete; but this is not effected, as has been ſuppoſed by the mere evaporation of its liquid part, or the water ſeparated from the elaſtic matter. I have aſcertained another cauſe of this ſeparation, which is a true concretion. I examined the juice of the hevæa, which was ſent me from the Iſle of Bourbon or Reunion, as well as that of Cayenne and the Brazils.

Theſe three juices might not perhaps be from the ſame tree, but they exhibit exactly the ſame properties with regard to the formation of the elaſtic ſubſtance. Each contains a white turbid liquor, of an inſupportable fetid ſmell, in the midſt of which is a white concrete matter, rather ſpongy at its ſurface, very elaſtic, of a ſoft, fine, and cloſe texture, which was the true caoutchouc: in a word, very pure, and of a quality much ſuperior to that of the utenſils prepared out of this ſubſtance in America. Theſe ſolid and elaſtic concretions had the form of the bottles that contained them, but were leſs in ſize: they had been depoſited by time and without evaporation, for the bottles were very well cloſed, and had loſt nothing. The juice which was contained in them, when expoſed to the air, became very ſpeedily covered with a cruſt of elaſtic gum. I accelerated the formation and ſeparation by combining the action of caloric with that of the air. In a veſſel filled with oxigen gas, the liquid afforded an elaſtic pellicle more ſpeedily, and a very ſenſible abſorption of gas took place. Alcohol ſeparated flakes, and the oxi-muriatic acid partially formed an elaſtic precipitate.

6. From theſe experiments I have concluded that caoutchouc is ready formed in the juice of the hevæa, and is capable of being ſeparated in the concrete form; that a portion is nevertheleſs not complete enough to be depoſited with its

elaſtic property; that it appears to want only a ſmall quantity of oxigen to complete its properties; that in this manner the contact of the air, the oxigenated muriatic acid had acted upon this ſubſtance; and that the atmoſpheric oxigen influences the concretion and ſolidification of caoutchouc in the fabrication of utenſils which are made in the hot countries where the hevæa grows. From theſe notions I have propoſed to import into France the juice of the hevæa, by adding the cauſtic alkali which prevents the elaſtic ſubſtance from precipitating, in order that we might be able to fabricate all the proper utenſils, or to plunge moulds in the juice upon which it might ſpontaneouſly depoſit the caoutchouc in a much purer ſtate than the concentrated and thickened juice which is uſed one ſtratum after another.

7. We ſee alſo that the pureſt caoutchouc is that which is ſeparated in this manner ſpontaneouſly from the juice of the hevæa while kept in cloſe veſſels; that our experiments ought rather to be made upon this than upon the ready-formed veſſels in order to determine its nature, and that it may be highly uſeful to employ this white concrete juice ſo depoſited for the purpoſes to which it is adapted, and which I ſhall point out at the end of the preſent article.

C. *Phyſical Properties.*

8. Pure caoutchouc is white or ſlightly fawn coloured, extenſible, elaſtic, compreſſible, reſuming its original dimenſions as ſoon as the external force is withdrawn. Its texture is denſe, brilliant, fibrous, and ſmooth, like that of an animal ſubſtance; it is ſoft and becomes ſofter by heat, and by this ſimple proceſs it may be moulded into any deſired form. Cold deprives it in part of its properties.

9. Its ſpecific gravity to that of water is as 9,335 to 10,000. It has neither taſte nor ſmell. When cut, and the parts preſſed together, they unite ſo intimately that they cannot be ſeparated, but form an homogeneous ſolid. This valuable property is frequently uſed for connecting fragments and ſlips of this ſubſtance.

D. *Chemical Properties.*

10. Caoutchouc, expoſed to a violent heat, becomes ſoft, melts, ſwells up, emits a fetid odour, curls like ſome animal ſubſtances, and at length takes fire with a bright oily flame; from which property it is uſed in its native country for giving light, in the manner of a torch or flambeau. When heated in a ſilver ſpoon, it becomes converted into a kind of black oil, which remains greaſy and adheſive, though expoſed

for ſeveral months to the air, and never again aſſumes its elaſtic property. When diſtilled in cloſe veſſels, it affords a ſmall quantity of turbid water, charged with an ammoniacal ſalt not yet well known, a denſe brown oil, partly concrete and fetid, with carbonated hidrogen gas and carbonic acid gas. It leaves a ſpongy coal in little abundance, with very ſlight traces of ſaline matter, and difficult to be burned. By theſe products we may obſerve that it approaches to the gluten of animal matters.

11. No union is known between ſimple combuſtible bodies and caoutchouc. The air produces no alteration in it. Boiling water ſoftens it, ſwells it like a ſkin, gives it ſemi-tranſparence, but does not diſſolve it. Caoutchouc thus ſoftened is very ſoluble in ether, though it is not ſo in its natural ſtate. We are indebted to Pelletier for this diſcovery, who has ſolved the problem ſo long ſought reſpecting the ſolubility of Caoutchouc, announced by Macquer in 1768, but which all chemiſts have found either difficult or impoſſible until this explanation was given by Pelletier.

12. The powerful acids with ſimple radicals act upon caoutchouc. Concentrated ſulphuric acid reduces it to the coaly ſtate, and blackens it at the ſame time that itſelf becomes ſulphureous. The nitric acid attacks, corrodes, and renders it yellow like cork, changes it into oxalic acid, and a fatty matter. The other acids have no action upon it; the cauſtic alkalis do not alter

it, nor reduce it to the ſaponaceous ſtate, which proves that it does not truly reſemble the fixed oils. The ſalts do not attack it, nor change its properties. The action of the oxides and metallic ſolutions upon theſe bodies have not yet been examined.

13. Among vegetable matters, the oils are the only ſubſtances which have an evident action upon caoutchouc. Fixed oils boiled upon this ſubſtance diſſolve it, as they alſo do melted wax; but it remains adheſive and viſcid in the ſolutions. The oils of lavender, aſpic, and turpentine diſſolve it by the aſſiſtance of a gentle heat; but the viſcid combination remains adheſive, incapable of drying, ſticking to the hands, and in fact of no utility. By the mixture of fixed and volatile oils it is diſſolved, in order to form that fat and flexible varniſh which is laid upon ſilk. A ſolution of caoutchouc in oil of aſpic, mixed with alcohol, throws down white flocks, inſoluble in hot water, which remain at the ſurface of this laſt fluid, and become white and ſolid like wax by cooling. Berniard, to whom we are indebted for this experiment, thinks that it precipitates a true concreſcible fixed oil; but this aſſertion is far from being ſufficiently accurate to be conſidered as well eſtabliſhed.

E. *Species.*

14. We are not yet acquainted with many ſpecies of caoutchouc, though it is probable there may be ſeveral different from each other, if not from their chemical characters, at leaſt with regard to their origin. From what has already been ſtated, we know that there is a white and pure caoutchouc depoſited from the juice in cloſed veſſels, and an impure caoutchouc dried in the air and in the ſmoke; but the latter differs from the former only in certain impurities which change it, and of which it is poſſible to deprive it by the ſucceſſive action of water, air, and of alcohol, aſſiſted by heat.

15. When we ſhall be better acquainted with the hiſtory of the different trees which are capable of affording caoutchouc, and when their products ſhall have been comparatively examined, we ſhall be able to diſtinguiſh, if not the ſpecies, at leaſt the modifications and varieties of this juice, and we ſhall then know whether we may hope to diſcover, in the plants and trees of our temperate climates, any materials capable of affording to the arts a ſubſtance of a ſimilar nature.

F. *Uſes.*

16. We may eaſily conceive that a hard, ſolid body, unchangeable in the air, inſoluble in water,

ter, not attacked by the greater part of the ſolvents, and which, to theſe valuable qualities, joins the ſtill more valuable quality of being powerfully elaſtic, muſt preſent a great number of important uſes to the arts: in medicine it is employed for the fabrication of bougies, peſſaries, bandages, and a great number of ſurgical utenſils, proper to diminiſh or even to cure a great number of diſorders. We muſt obſerve that all theſe utenſils are capable of becoming ſoft, and extended by the heat and contact of animal humours, and conſequently that it is neceſſary to attend to this property, in order to give ſuch a form to the article in queſtion as may admit of the augmentation of volume they undergo. In order to make catheters of pure caoutchouc, this ſubſtance, ſoftened and ſwelled by water, is diſſolved in ether, and its ſolution applied in ſucceſſive layers upon moulds of wax, which are afterwards melted out in boiling water.

17. In countries where the trees which afford this ſolid, elaſtic and inflammable juice grow, flambeaux and torches are fabricated, which ſerve to give light, and alſo veſſels and inſtruments applicable to many uſes. Thoſe veſſels retain water and various liquors very well, and communicate neither taſte nor ſmell to them. Boots and ſhoes are made of it, which are very durable, and yield to the motion of the parts.

18. In Europe, the bottles or veſſels of caoutchouc which are imported and cut into pieces

or ſtripes, are uſed to efface lines of black-lead pencils, and alſo for garters, for elaſtic re-action-pieces in machinery, and particularly for inſtruments of natural philoſophy and chemiſtry. It is diſſolved in oily mixtures, to be applied as a varniſh impenetrable to water upon ſilk for the purpoſe of clothing, or the conſtruction of aeroſtatic machines. But moſt of theſe varniſhes have the inconvenience of ſoftening and becoming very adheſive when expoſed to the rays of the ſun or to heat.

ARTICLE XVIII.

Concerning the Fifteenth of the immediate Materials of Vegetables; Balſams.

A. *Situation.*

1. BUCQUET was the firſt chemiſt who diſtinguiſhed, in 1774, the natural balſams from the reſins and gum-reſins, by conſidering as ſuch the reſinous juices which are conſtantly united to an acid, namely, the benzoic acid, and by giving them as proper characters, that of affording this concrete acid by ſublimation with the action of fire, and giving acidity to water, in which they were fuſed and boiled for a certain time. This denomination ſo determined, at laſt fixed the value of the term, which was till then

vague and uncertain, becauſe it was before attributed to reſinous juices, as well on account of their liquidity as their fragrant and agreeable ſmell, and alſo to oily and alcoholic compounds, to which this property was communicated by the mixture of ſeveral matters more or leſs odorant. It is with ſo much more propriety attributed to bodies of this genus, becauſe the aromatic volatile acid they contain gives them a lively ſmell.

2. All that has been ſaid reſpecting the properties of volatile oils, leaves no doubt reſpecting the acidifiable characters of theſe ſubſtances, and conſequently their origin and the formation of natural balſams, becauſe theſe appear in fact to be merely volatile oils, of which the oxigenation has converted part into reſin, and part into acid: and accordingly theſe matters appear to poſſeſs the ſame ſituation in vegetables as thoſe oils; and though the natural balſams are yet little employed and known but in a ſmall number, the number is ſufficient to confirm this notion, and to allow us to regard theſe products as exiſting in many of the parts of vegetables.

B. *Extraction.*

3. We have yet few accurate notions reſpecting the manner in which moſt natural balſams are procured. We ſee nevertheleſs by the example of the balſam of Peru, that theſe matters flow from trees in the ſoft and viſcid form of turpentine, ſince they are collected in entire

cocoa-nut ſhells, in which they become condenſed and ſolid.

4. When we ſhall be more intimately acquainted with the great number of vegetables that contain balſamic juices more or leſs concrete, and volatile oils converted into reſins or acids, we ſhall be able by applying proper ſolvents or more particularly alcohol, to obtain thoſe immediate products, and increaſe the claſs of materials ſo important for the arts. This practice is already conſiderably advanced, without a proper attention to the progreſs of the ſcience, by treating ſeveral vegetable matters with alcohol, which, as we ſhall ſee in the expoſition of theſe ſpecies, are really charged with balſam. A kind of ſolid balſam is fabricated by condenſing in the air, or by heat, ſuch volatile oils as are moſt diſpoſed to acquire this ſtate of reſin or of acid.

C. *Phyſical Properties.*

5. The balſams can never be as liquid and as light as the volatile oils, becauſe they are always produced by an alteration in theſe laſt. They are therefore condenſed viſcid juices, flowing with ſlowneſs and difficulty, ſpeedily aſſuming the concrete form of a brown or ruddy colour, of an agreeable aromatic ſmell when compreſſed, rubbed or heated, and particularly when perforated with an ignited pin.

6. Their ſpecific gravity lies between 1, 1 and 1,0. They all exhibit an acrid and ſtrong

ſmell when maſticated for a time. They redden blue vegetable colours when their powder is mixed with thoſe colours diſſolved in water. When heated they melt, and ſoon exhale a white vapour of a very ſtrong and penetrating ſmell. By cooling after fuſion they preſent on their ſurface a white needled or ſnowy powder. The heat which fuſes them produces alſo a partial decompoſition.

D. *Chemical Properties.*

7. All the chemical properties of the natural balſams ſhow that theſe ſubſtances are compounds of reſins and benzoic acid. Many of theſe properties being analogous to thoſe of the reſins, we ſhall inſiſt only upon ſuch as are proper to diſtinguiſh them, and which are owing, as we ſhall ſee to the preſence of benzoic acid in theſe juices.

8. When they are heated ſtrongly with the contact of the air, they afford during their fuſion and ſwelling up, a very odorant white fume, of a ſharp acrid ſmell, exciting cough and tears, which when diffuſed in the air, communicates an agreeable perfume. It is the true incenſe. When heated in cloſed veſſels, the ſubſtance of this vapour becomes condenſed in cryſtalline needles, or plates, of an acrid nature. In a word, we obtain the benzoic acid of which I have fully treated in one of the preceding articles, and which amounts to one fifth of their weight.

After having afforded this product, the reſidue is ſimply a reſin.

9. In the air they are not liable to change, though expoſed in a dry and concrete ſtate; if they be ſtill ſoft they dry and ſometimes ſuffer a ſmall portion of their acid to exhale, when the air is very hot, which effloreſces on their ſurface, and covers them with a powder reſembling ſnow or ſmall white needles, which have been called the flowers of certain ſubſtances.

10. The water in which they are boiled ſoftens and fuſes them, and diſſolves part of their acid, which may even be obtained ſeparate and cryſtallized by cooling, as Geoffroy firſt ſhowed at the commencement of the eighteenth century; but we cannot obtain by this means more than a ſmall portion of their benzoic acid; the greateſt part remaining fixed and enveloped by the fuſed reſin: ſo that we cannot have an accurate analyſis by this proceſs, which merely proves that the balſams contain a concreſcible and volatile acid.

11. The acids do not act upon the balſams; the alkalis ſeize their benzoic acid and form ſoluble benzoates. Lime is more particularly employed to attract the acid, after the manner of Scheele, as I have already obſerved in the article of acids.

12. The balſams are ſoluble like the reſins in oils, particularly volatile oils, and form ſolutions of different degrees of denſity and viſcidity, which are frequently prepared for pharmaceutic uſes.

E. *Species.*

13. I HAVE already obſerved that more vegetable balſamic ſubſtances exiſt than are reckoned in the materia medica. Hitherto we have known only benzoin, the balſams of Peru and Tolu, which are confounded together, and ſtorax, to which muſt be added the common ſtorax of the ſhops, as a variety of ſtorax. I add to theſe well-known ſpecies the balſam of Vanilla and that of Canella, becauſe theſe two ſubſtances contain volatile oil and benzoic acid, in the proper condition to form true balſams.

A. Benzoin: two ſorts are diſtinguiſhed, the benzoe amygdaloides, formed of white tears reſembling almonds, connected by a brown cement. It reſembles our *nougat.* Common benzoin is brown, and without tears; it emits a very pleaſant odour when fuſed, or when punctured with a heated needle. The tree which affords it is little known. Driander calls it ſtyrax benzoifera. Murray however obſerves that the bark of the wood of this tree emits the odour of benzoin even when burned. According to him it is very doubtful whence this balſam comes.

Benzoin is exported from the kingdom of Siam, and the iſle of Sumatra. It affords very little volatile oil on account of its ſolidity. Boiling water extracts an acid ſalt in needles, of a ſtrong ſmell, which cryſtallizes by cooling; it is alſo obtained by ſublimation, and was formerly called flowers of benzoin. This operation is made in two glazed earthen veſſels, one above the other, and luted together with paper. For this purpoſe a very gentle fire muſt be applied, otherwiſe the ſalt will be brown. The paper cone which was formerly uſed for this purpoſe ſuffers much of the concrete acid to eſcape. I have ſhown the properties of this acid in one of the preceding articles. Benzoin afterwards diſtilled by the retort, affords a very acid phlegm, a portion of concrete and brown acid, brown and thick oil, and a coal which remains contains a ſmall quantity of pot-aſh, and ſome traces of alkaline and calcareous ſalts.

Benzoin is ſoluble in alcohol, and its tincture precipitated by water conſtitutes the lac virginale. The ſalt of benzoin or benzoic acid is employed as a good detergent in pituitous diſorders of the lungs or the reins. Its oil is diſcutient, and is externally uſed for paralyzed limbs, &c. Benzoin in a crude ſtate is uſed as incenſe.

B. Balſam of Tolu. This comes to us in yellowiſh tears, or in a fluid ſtate. It flows from the toluifera, placed by Linnæus in the claſs of the decandria monogynia. We receive it from South America, between Carthagena and *Nombre-de-Dios*, which the iſlanders call Tolu, and the Spaniards Honduras. It affords by analyſis the ſame products as benzoin, and particularly a concrete acid ſalt; it is uſed in diſorders of the lungs, and is made into a ſyrup.

C. Balſam of Peru: modern naturaliſts diſtinguiſh balſam of Peru from that of Tolu. It flows in fact from a different tree, and comes to us in reddiſh tears, or elſe incloſed in cocoa-nut ſhells. It is extracted by plunging thoſe ſhells in boiling water, which ſoftens it, and cauſes it to flow out. It preſents the ſame chemical properties, and is applied to the ſame uſes as the preceding balſam. Its ſmell is ſomewhat different when immediately compared with that of balſam of Tolu.

D. Storax is a ſolid balſam, in red dry tears, or elſe brown and adheſive: it has a very ſtrong ſmell. It flows from the oriental liquid amber, a plant little known. Duhamel obſerved a juice of the ſame ſmell flow from the aliboufier. Neumann analyzed pure ſtorax, and obtained very little volatile oil, a concrete acid ſalt, and a thick oil.

Its uſe is ſimilar to that of benzoin; it is eſpecially employed for perfumes.

Formerly it was imported encloſed in reeds, on which account it received the name of *ſtyrax calamita:* at preſent it is brought to us in the form of cakes, or irregular maſſes, of a reddiſh-brown colour, mixed with ſome tears of a lighter tinge, and of a very pleaſant ſmell.

The common ſtyrax, employed for the preparation of the ointment which bears its name, is a liquid juice proceeding from the ſame tree as the ſtorax; it is the groſſeſt and moſt impure part of the liquidambar; it contains much impurities, and portions of bark. Citizen Bouillon-la-Grange has made a chemical examination of it; he has found that it becomes clotted, and much ſwelled by the action of the fire; that much of it is loſt in attempting to purify it by fuſion and ſtraining, as has been propoſed in pharmacy. He has extracted benzoic acid from it in conſiderable abundance by means of lime; has propoſed to purify it by means of alcohol, and to employ it thus purified for the preparation of the ointment. When obtained by this proceſs, it aſſumes moſt of the properties of true ſtorax.

E. I admit a balſam of vanilla, though it is not yet known, and has not been extracted, becauſe benzoic acid may be volatilized from this legume, and becauſe it contains a reſin in conſiderable abundance. By treating vanilla with alcohol, and afterwards evaporating its alcoholic ſolution or tincture, this balſam will be obtained, which will preſent the characters of ſtorax.

F. I can ſay the ſame of cinnamon, as it affords volatile oil in abundance by diſtillation, and as its diſtilled water depoſits cryſtals of benzoic acid by cooling. There is reaſon to believe, that by treating cinnamon with alcohol, and evaporating the ſtrong tincture thus obtained, a real balſam of cinnamon will be extracted, brown, odorous, fuſible, affording benzoic action by the fire, &c.

F. *Uſes,*

F. *Uſes.*

14. THE balſams, as we have ſeen, are much employed in medicine. They are ſtill more employed in perfumes; for the latter uſe, they are made up in all ſorts of forms. They prevent and retard the putrefaction of animal matters, and are extremely uſeful in embalming, which derives its name from them. Sometimes the perfume is combined with alcohol and ſugar, in preparing *liqueurs* for the table, &c.

ARTICLE XIX.

Of the Sixth of the immediate Materials of Vegetables; colouring Matters.

A. *Situation.*

1. THE coloration of vegetables, and of their different parts, is one of the moſt beautiful phenomenona which the vegetable economy preſents. It has at all times excited the attention of philoſophers, and they have been inceſſantly engaged in inveſtigating its cauſe. Chemiſts have believed, after a multiplicity of reſearches, that it proceeds from a particular matter, which they have denominated *colouring principle;* but they ſoon found that this

pretended principle, inſtead of being identical and conſtant, was very much varied in its properties, and ought not to be conſidered as always one and the ſame matter. Were it even well proved, what the great Newton has advanced, that the different coloration depends upon the diverſity of the ſurfaces, and the manner in which each of theſe ſurfaces reflects or refracts the rays of the light, it would immediately reſult that the very difference of the external ſurfaces of theſe bodies muſt imply a difference in the texture and compoſition of each of them. Thus from the mere circumſtance that the colours and the different parts of vegetables are very much varied, it follows that this variety itſelf muſt be neceſſarily connected with that of their nature : which evidently proves that no identical colouring principle can be admitted in plants.

2. The ſlighteſt obſervation of vegetables proves that, beſides the green colour which is generally diffuſed throughout their foliage, their different parts are tinged in a very different manner; that none of them entirely reſembles another in this property, and that the ſeat of what are called colouring parts is diſſeminated throughout all their organs, almoſt with a kind of indifference, which ſhows that this property of the coloration itſelf is, if I may uſe the expreſſion, of very little expenſe to nature, and that it is as it were the neceſſary conſequence of all the phenomena of vegetation.

3. However, the ſame obſervation, though haſty, is equally ſufficient to ſhow that the contact of the light has ſo much influence upon the formation of the colouring parts, that it ſeems even neceſſary for their production. The barks, from the epidermis to the cortical layers, are conſtantly more coloured than the interior of the trunks and of the trees. The leaves, as they are unfolded out of their buds, are of a pale green colour, which gradually darkens in proportion as they develop themſelves in the air; thoſe that unfold themſelves in the ſhade are white and inſulated like the ſtalks or the branches. At the moment when the flowers open or protrude themſelves out of the calixes in which they were folded up or encloſed, they are for the greater part without colour, and acquire a tinge only in proportion as they are expoſed to the air and to the ſun. However, it ſeems that an exception is found to this rule, when we ſee the roots and fruits preſent even in the interior of their texture, which is always deprived of light, in ſome inſtances a very marked coloration; and it is frequently in the profoundly hidden parts that the moſt beautiful and moſt durable colours are found for the art of dyeing. The force of this objection is diminiſhed when we obſerve that theſe coloured roots and fruits belong in general to vegetables that have been long immerſed in light, that grow in latitudes where the rays of the ſun ſtrike them vertically, that have a ſtrong and

durable vigour in their vegetation, and in which conſequently the influence of the luminous principle penetrates even into the moſt intimate and moſt remote organs of their ſtructure.

B. *Extraction.*

4. SINCE the colouring matters muſt be acknowledged to be more or leſs numerous and different from one another, it is evident that the means of extracting them muſt vary according to their nature. I do not ſpeak here only of the coloured parts of vegetables which, in their maſs, require only to be ſeparated from thoſe that are not coloured, and which need only be ſorted and collected, or mechanically ſeparated from each other. Thoſe are only the reſervoirs of the colouring matters; they are only ſurfaces, moſt frequently hard and ligneous, to which the true colouring parts are glued as it were, and adhere like varniſhes. They require to be ſeparated or detached from theſe ſurfaces.

5. This ſeparation cannot be effected by mechanical means, becauſe the colouring matters are of an extreme tenuity, and moſt frequently in a ſtate of ſuch dryneſs, and at the ſame time adheſion to the parts which they cover, and in ſome ſort decorate, that it is only by chemical proceſſes that we can ſucceed in ſeparating them. Recourſe is almoſt always had to different ſolvents, according to the diverſity of thoſe matters. Cold or hot water,

ter, long ebullition, ſometimes the alkaline matters or other re-agents applied to theſe coloured vegetable bodies, are the principal means that are put in practice, as well in chemical operations, and with a view to examine their nature as in the proceſſes of dyeing, and with the intention of afterwards applying the colours to the threads, the textures, and the ſtuffs deſtined to receive them.

6. Sometimes the vegetable colouring part is diſſolved or diluted in vegetable liquids and then they need only to be extracted by preſſure; but this caſe ſcarce ever obtains, except with the green colours and the fecula, which are their vehicle; and though it is frequently obſerved by the chemiſt in his experiments, it but very rarely preſents itſelf to the dyer in his practice. And even with the chemiſt himſelf, it is of all the circumſtances relative to the extraction of the vegetable colouring parts, the leaſt frequent; for it has really no application, except for the green colours.

7. There are many circumſtances in which the chemical art is not confined, as to the preparation of theſe colours, to the extraction of theſe matters from the vegetable ſubſtances which contain them; it frequently extends itſelf even to the proceſſes for modifying or actually forming them, either by a ſeries of ſpontaneous alterations of which they are ſuſceptible by fermentation and agitation in the air, or by mixing them with different ſubſtances which, whilſt they render them more ſoluble, mo-

dify them, and cauſe them to paſs into the ſtate which the art requires. It is in this manner that the fecula of the indigo plant and of the paſtel is made to paſs from the green into the blue ſtate, the grey or fawn-coloured powders of the lichens into the brilliant red of the archil, &c.

C. *Phyſical Properties.*

8. In treating of ſubſtances ſo various and ſo numerous as the colours of plants, it is impoſſible to occupy the mind with any other properties beſides their coloration itſelf; and this phenomenon alone preſents in itſelf a ſufficiently beautiful ſeries of obſervations and gradations to merit ſome particular conſiderations. Amongſt the multiplied varieties of colours with which the vegetables are adorned, we find that the green is the moſt abundant and moſt univerſally diffuſed; and that this green, which inceſſantly varies in its ſhade, and which firſt paſſes from the pale to the deep green, afterwards undergoes a degradation in all vegetables, till it terminates in a more or leſs fixed and pronounced fawn-colour, which is known by the name of *dead leaf.* We afterwards find that the yellow is alſo one of the moſt frequent vegetable colours, and at the ſame time that it is the moſt permanent and the leaſt alterable colour that is known. We then

ſee the blue and the red alſo preſent themſelves in great abundance, and exhibit extremely varied tinges, the ſhades and qualities of which are no leſs intereſting to the eye than aſtoniſhing, on account of their inconceivable multiplicity. Finally, obſervation proves alſo, that amongſt the mixed colours, there are a multitude which reſult from the union or the mixture of two or more colouring matters; whilſt there are others of a ſimple and primitive compoſition.

9. The primary cauſe of the coloration of all bodies appearing to depend upon the different properties which theſe bodies have of reflecting different rays of light; it is of importance here to remark that the weakeſt reflection exhibits the blue rays approaching to black, that the yellow ray depends upon a more conſiderable reflection, and that the red is that which indicates the ſtrongeſt reflexion. We may add to this conſideration, that the ſame order ſeems to be obſerved by nature in combuſtion and coloration of flames. The moſt feeble combuſtion produces a blue light; a ſtronger inflammation gives a yellow light, and the moſt energetic gives riſe to the white, the conſequence of the total reflection of the luminous rays. It ſeems that there is here alſo ſome analogy with the phenomenon of the oxidation of metals. The leaſt oxided are black or blue; as they become more oxided, they paſs into the yellow and orange ſtates; and when ſurcharged

charged with oxigen, they become red and white. In the ſame manner, the colour of the maſſes of air is blue, as well as the light of the moon received upon white bodies, like that which ſurrounds the ſhade of bodies projected upon white ſurfaces. Whatever ingenuity there may be in theſe approximations, they however teach us nothing poſitive reſpecting the nature of the colouring parts, nor have they yet any exact relation with their chemical properties.

D. *Chemical Properties.*

10. Though according to the diverſities already announced in the vegetable colouring matters, it is really impoſſible to give generic characters which apply to them all; though it is evident that their exact hiſtory can only be ſpecific, it is however uſeful to ſeek amongſt the generality of their properties ſome of thoſe which, being more or leſs diſtinctly marked as characteriſtic of theſe ſubſtances, and not belonging to ſubſtances of another genus, muſt juſtly be conſidered as belonging excluſively to them. It is very evident that it cannot be in the ſame order which has been adopted for all the immediate materials hitherto treated of, that this table can be conſtructed; as they do not really reſemble any of thoſe materials, their chemical hiſtory muſt alſo be in a certain degree independent of them. The firſt chemiſts who

have occupied themſelves with the examination of theſe colouring matters, Hellot, Lepileur d'Apligny, Hecquet d'Orval, Mazéas, Macquer, and Poerner, have only committed errors, nor could they do otherwiſe. It is only ſince the happy data of the pneumatic doctrine that Citizen Berthollet has begun to throw the greateſt light upon this department of the ſcience, and that Citizens Hauſſman and Chaptal have alſo increaſed our knowledge reſpecting it.

11. It is particularly by the chemical attractions which the colouring vegetable matters exerciſe upon the acids, the alkalis, the earths, the metallic oxides, oxigen, and the textures, from wool to flax, that theſe matters are eminently diſtinguiſhed from the other vegetable matters, as Citizen Berthollet has firſt ſhown. Their attraction for alumine, and the metallic oxides, is ſo great that they frequently ſeparate them from the acids, and are precipitated with them from their common ſolvent. Their union with thoſe earthy or metallic baſes modifies their colours, frequently changes them, but renders them, on the one hand, more permanent than they were before, and leſs ſenſible to the action of the air, and of the other external agents.

12. One of the principal and moſt eſſential characters of the colouring parts, is their alterability and mutability by the contact of the air and of the light. In general, the oxigen is abſorbed by theſe matters, which paſs into the

yellow, the brown, or the cheſnut-red, according to the proportion of it which they contain. Many, at the ſame time, loſe a portion of their hidrogen by a real ſlow combuſtion; and then the predominant carbon eſpecially contributes to make them paſs into a higher degree of coloration, and into caſts more and more intenſe. Thus, in general, all the vegetable colours experience this double effect from the action of the air; they abſorb oxigen from it, and ſuffer a portion of their hidrogen to be diſſipated; in ſuch a manner, however, that the conſequence of the firſt effect is in general a formation of red or brown tinges, and that of the ſecond a perpetual tendency towards the black, towards the coaly ſtate, towards one of the terms of the vegetable decompoſition. The nitric acid, the ſulphuric acid, and the oxigenated muriatic acid, act in the ſame manner upon the colouring parts. I have made it appear, in a particular inquiry upon the vegetable matters diſſolved in water, that all of them have more or leſs colour, that their coloration is augmented by the contact of the air and the abſorption of oxigen; that determinate proportions of the latter produce certain fixed compounds at a certain temperature, the character of which is to have ſuch or ſuch a colour; that the *maximum* of this colouring oxigenation is, after having paſſed through the reds and the browns, to produce the yellow, the moſt conſtant, the moſt fixed, and the moſt unalterable of the natural colours of vegetables. Citizen Berthollet, on his part, has conſidered the dark brown and black coloration by the contact of the air, as the product of a combuſtion of the hidrogen, and of the denudation of the carbon,—as a kind of ſlow combuſtion. He has ſhown that the ſolidity, the fixity of the vegetable colours depend upon the greater or leſs diſpoſition which theſe parts had to experience this combuſtion.

13. In proportion as the colouring matters experience the firſt of theſe effects, or the abſorption of oxigen, which combines entirely with them and changes their hue, they in general ceaſe to be ſo ſoluble in water as they were before; they even become entirely inſoluble in this liquid; they at the ſame time acquire ſolubility in the alkalis and in alcohol; they appear to approximate much to the nature of the oily matters, to hold a ſort of middle rank between the reſins and the fats, without however being exactly either the one or the other; they are what I have called the *oxigenated extractive*; for the greater number of the vegetable colours have the character of what has been deſignated by the name of *extracts*. The ſame is the caſe with thoſe which have acquired darker colours by the loſs of their hidrogen, and the ſuperabundance of their carbon; by becoming blacker they have become leſs alterable, leſs ſenſible, leſs ſoluble, and it is even remarked that the colouring parts that are naturally the moſt ſolid, the leaſt changeable, the moſt durable or permanent,

owe this property to the conſiderable proportion of free carbon which they contain. Accordingly they are generally prepared by a preliminary and more or leſs advanced combuſtion of their hidrogen, which takes place more eſpecially in the fermentations which are employed for indigo, paſtel, woad, &c.: it is on this account that theſe colours, though ſtill ſuſceptible of being in ſome degree changed by oxigen, are more capable of being diluted than diſſolved.

14. The colouring matters unite eaſily with the metallic oxides, and experience in the union which they contract with them, a combuſtion proportionate to the quantity of oxigen which they can take from them; thus the colours of theſe combinations are, as Citizen Berthollet has remarked, a product of that which is peculiar to them and to the oxide, *plus* the oxigen added to the firſt, and *minus* that which is taken away from the latter; for we muſt calculate this double effect which modifies the colour of each of theſe ſubſtances. Hence the oxides with which oxigen has little adheſion, are the leaſt proper for attracting and fixing the vegetable colouring matters, which they burn too ſtrongly, as do thoſe of gold, of ſilver and of mercury; thoſe which yield too much of it, and experience great changes in their own colour, ſuch as thoſe of biſmuth, of lead and of copper, are alſo bad intermediates: the moſt proper for attaining the object of fixing colours without altering them, are thoſe which re-

tain the oxigen with force, and the colour of which is little changed by yielding a portion of it. Thus the oxide of tin, which has little adheſion with the acid ſolvents, and is ſtrongly attracted by the colouring parts, giving them a baſis of a beautiful white, which exalts their luſtre whilſt it weakens their tinge, has the greateſt advantages in dyeing.

15. This ſimple theory explains the effect produced upon the ſolutions of the colouring parts by the metallic ſolution; and eſpecially the precipitation occaſioned in it by the ſuper-oxigenated muriate of tin. There is ſome analogy between this effect and that of alumine; which unites very eaſily with the colouring matters, which frequently abandons its acid ſolvents to combine with it; which, by precipitating itſelf along with them upon the ſtuffs, favours their adheſion and ſtability, and which, by its pure white, renders their tinge clearer, whilſt at the ſame time it ſtops the progreſs of their combuſtion, both in the fixation of the oxigen, and in the diſengagement of the hidrogen. Such is the idea that ought to be formed of the action of the mordants. Amongſt theſe, the aſtringent vegetable ſubſtance, eſpecially that which is contained in the nut-gall, ſumac, and the bark of the oak, the effect of which upon the ſtuffs ſo frequently ſerves as a preparation preliminary to the dyeing of them, is eſpecially uſeful by its eaſy combuſtion and carbonization by the contact of the air, by the property of ſoon ſtopping

ping in its combuſtion, and abſorbing little oxigen, by its attraction for the matters of the textures, and eſpecially of thoſe that are of an animal nature, as well as to the different colouring parts, which it alſo attracts and firmly fixes upon the ſtuffs, to which it communicates its own ſolidity. This is the reaſon why galling is ſo frequent and ſo advantageous an operation in dyeing. The aluming, which is afterwards practiſed, renders the colouring matter more adherent and clears it, eſpecially when the precipitation of the alumine is favoured by the addition of the acetite of lead to the alum which it decompoſes, forming acetite of alumine, the baſe of which is much more eaſy becauſe ſeparated and precipitated, it adheres leſs to the acetous acid.

16. It has long ſince been remarked that the colouring matters have a ſtrong attraction for animal ſubſtances, that they ſeize upon theſe ſubſtances more quickly, and adhere to them much more ſtrongly than to the vegetable ſubſtances. Thus wool and ſilk are the ſubſtances which take dyes the ſooneſt, and retain them the longeſt, whilſt flax and hemp are the moſt difficult to be dyed. This appears to proceed from the circumſtance that the colouring matters are of an order of compoſition that approaches to that of the animal matters; they differ in fact from the gums, the ſugar, the oils, the reſins, the acids, by the preſence of azote, which forms one of their primitive principles, and it is

to this that they owe the property of affording ammonia in their analyſis by fire; they approach in this circumſtance to the nature of the extractive matter, in the hiſtory of which I have pointed out the ſame character, and of the ligneous ſubſtance, concerning which I ſhall treat in one of the ſubſequent articles. The colouring ſubſtance alſo adheres in general, or is found moſt frequently under both forms in vegetables; and when authors attempted to give a chemical definition with regard to its properties and its nature, it has been conſidered either as an extract, or as a ligneous ſubſtance.

17. Though what has hitherto been ſtated concerning the chemical properties of the colouring matter, might ſuffice to characterize it as a genus, and though the more ample details belong rather to the hiſtory of its ſpecies, I muſt not however omit mentioning in this place, that before the modern diſcoveries, which have led to the general conſiderations which I have juſt enumerated, chemiſts, eſpecially Macquer and Bucquet, had diſtinguiſhed theſe colours, which they already knew to be very much varied and very different from each other, into, a. *extractive* or *ſaponaceous colours*, entirely ſoluble in water, ſo that they could not be precipitated upon the ſtuffs unleſs by the action of the mordants which decompoſe them; b. *reſino-earthy colours*, the character of which was to melt and dilute themſelves only in water with the aid of heat, ſo that they were precipitated from it by

mere cooling, and adhered to the ſtuffs which were kept immerſed in their baths; c. *reſinous colours*, inſoluble in water, ſoluble in the alkalis, and frequently in alcohol; d. *oily colours*, ſoluble particularly in the oils. But theſe diſtinctions are too few and at the ſame time too inaccurate; for they afford only a very imperfect idea of the diverſities of the colours, and of their true diſtinctive characters, though it is indeed very difficult to give ſuch as ſhall be much more preciſe and ſatisfactory.

18. There is another difference relative to the vegetable colouring parts, the inquiry into the cauſe of which is of much greater importance, namely, that which relates to the nature of the coloration itſelf. In general only three primitive or principal colours are known in vegetables, namely, blue, yellow, and red; and there is reaſon to believe that each of theſe primitive colours is a determinate combination of the principles which conſtitute the colouring matters. Nothing is yet made out in the ſcience reſpecting the difference of theſe three colours: all that is known is, that of the three the yellow has in general the moſt permanency and ſtability; that the blues are much varied in their properties, that the reds lead to the brown and the black. We are conſequently ſtill more ignorant of the intimate cauſes, or the multiplied combinations formed by the very numerous ſhades of theſe three colours, the parents of all the reſt.

E. Species.

19. The hiſtory of the ſpecies is very truly, as I have already announced, that of the vegetable colouring matters, ſince theſe ſpecies, conſtituting a ſeries of real differences amongſt themſelves, require to be examined one after the other, and afford the only means which exiſt of drawing from their general compariſons the relations which they may have, and the characters by which they may be united as a genus. But this ſpecific hiſtory ſeems not yet to form part of the ſcience. As the whole belongs to the art of dyeing, it preſents, inſtead of a perfect knowledge of the vegetable colours, only a ſeries of proceſſes for extracting them, ſeparating them from their ſolvents, precipitating them upon the ſtuffs, cauſing them to adhere to them, and rendering them more or leſs ſtable, fixed, permanent and unalterable. It is not, however, the art which we are here to deſcribe; for this is altogether contained in that part of the ſcience which I deſignate by the word *application*, and muſt be treated after we have gone through the three firſt branches of the chemical ſyſtem. I muſt borrow from this ingenious and important art ſo much only as may throw ſome light upon the properties of the colouring matters.

20. The difficulty of diſtinguiſhing and claſſing the ſpecies of vegetable colouring

matters, proceeds eſpecially from the circumſtance that we do not exactly know the nature of each of them; accordingly it is impoſſible to diſpoſe them, at leaſt in an exact and ſatisfactory manner, according to their chemical properties; it is very evident that the diviſion of Macquer can no longer be adopted. What can be done in this reſpect, reduces itſelf to the conſideration of theſe colouring matters as forming four genera hitherto very inaccurately divided, the diviſion of which muſt be a mere outline. Theſe four genera are, 1. the pure extractive colours; 2. the oxigenated extractive colours; 3. the carbonated colours; 4. the oily or reſinous hidrogenated colours.

21. We may rank the firſt genus, namely, amongſt the *pure extractive colours*, thoſe which appear in fact to be entirely ſimilar to the extractive, which are perfectly ſoluble in hot water, which do not quit this ſolvent by cooling, which cannot be applied to the ſtuffs unleſs by the help of the ſaline or metallic mordants that decompoſe them, and oxide them in ſuch a manner as to render them inſoluble. By theſe means, and by employing tartar, alum, the acids, and eſpecially the metallic oxides and ſalts, they are made to approach to the nature of thoſe of the ſecond genus, oxigen is furniſhed to them, their colour indeed is changed, they are modified in a manner which we ought to know previous to uſing them; but they are ſeparated from the water, and they are made to depoſit themſelves

upon and attach themſelves to the ſtuffs. To this genus belong the Campeachy and Brazil woods, the yellow wood, madder, veld, and the firſt colour of the carthamus or baſtard ſaffron. All theſe colouring parts diſſolve in water, which they tinge more or leſs ſtrongly according to their colour; when mixed with alum or muriate of tin, and precipitated afterwards by an alkali, they afford lakes.

22. I place in the ſecond genus of oxigenated extractive colours, thoſe which have experienced, as it appears, by the effect of vegetation, a change in their nature, depending upon the abſorption of oxigen, which have therefore ceaſed to be ſoluble in water, as they originally were, and are ſuſceptible only of being ſoftened, melted and diſſeminated in this boiling liquid in ſmall flakes, which are precipitated from it by cooling, and conſequently depoſited ſpontaneouſly upon the ſtuffs, adhering to them and dyeing them in a ſolid manner. The dyers call them *root-colours*. It is ſufficient to keep the ſtuffs for ſome time immerſed in their bath for them to acquire a fixed colour; and this is almoſt always more or leſs of a fawn colour. The root of the patience, the wood and bark of the alder, and of the oak, ſumac, the huſk of the walnut, and the nut-gall, are of this kind. We may alſo refer to it almoſt all the barks, the woods and the roots, from which are ſeparated, in the pharmaceutical art, ſolid extracts, that become brown

in the air, and the decoctions of which become turbid, and afford a depoſit by the contact of the atmoſphere.

23. In the third genus I comprehend the colours which I call carbonated, becauſe all their properties announce that they contain a large proportion of carbon to which they owe their ſolidity and fixability. It is theſe upon which the modern diſcoveries have began to throw the greateſt light, and the nature and principal properties of which Citizen Berthollet has explained in his memoirs, as alſo in his elements of the art of dyeing. Before him, chemiſts had very falſe ideas concerning them, or rather they had no accurate ideas, nor ſatisfactory notions of them. They believed them to be oily or reſinous matters, whereas they are really neither the one nor the other. Notwithſtanding the fine analyſis of the indigo, the moſt remarkable of theſe colours, which was given by Bergman, nothing exact had yet been aſcertained reſpecting theſe ſingular matters, previous to the happy application which Citizen Berthollet made of the pneumatic doctrine to the theory of colouring matters. Theſe, which comprehend in their genus annatto, archil, indigo, and paſtel or woad, are not ſimply extracted by the action of water from natural vegetable ſubſtances which contain them ready formed; they are the product of a more or leſs profound alteration, of a more or leſs advanced decompoſition, of a real combuſtion effected by putrefaction, in which the hidrogen has been

exhaled more or leſs ſpeedily, and the carbon has been ſet free. They are diſſolved or diffuſed in the alkalis or alkaline matters, and ſometimes by very particular proceſſes, of which I ſhall ſay a word hereafter. They are all ſuſceptible of another order of fermentation which burns them more ſtrongly, and reduces them to the pure coaly ſtate.

24. I make a fourth genus of vegetable colouring matters, which I call *hidrogenated or reſinous* colours, becauſe they are really of this nature: they are diſtinguiſhed by their inflammability, their inſolubility in water, and their ſolubility in the oils and in alcohol. The root of alkanet gives a brilliant red colour to oils. The coloured reſins, dragon's blood, the reſin of the ivy, that of guaiacum, the gum-reſins, contain this kind of colouring principle in abundance. It is perhaps one of the moſt frequent in the vegetables, ſince there is none of them that does not give colour to oil or alcohol. But theſe colours, though holding a very remarkable place amongſt chemical facts, occupy only a very ſmall one in the art which is occupied with their extraction and application; for they are ſcarcely, if at all, employed in dyeing. The roſe itſelf, a flower ſo delicate and tranſient that it has always been taken by the poets as the ſymbol of beauty, gives a tinge to alcohol which becomes reddiſh by the action of the acids, and green by that of an alkali. It is to this order alſo that we are to refer the green colour, ſo

univerſally diffuſed amongſt plants, and which is nevertheleſs ſo alterable that it can never be preſerved. This colouring part is ſoluble in the oils and in alcohol. There are alſo certain vegetable colours which belong to none of the four preceding genera, as they have not their characters, and there is ſcarce any means of diſſolving them: ſuch is the yellow of the flowers, and eſpecially that of the petals of the ranunculus, and of ſeveral other flowers that are equally unalterable. This general diſtinction of colouring matters into four genera is not ſufficient for conſidering their ſpecies. It is neceſſary to treat of them under another point of view, and by deſcending to each of them, to conſider them with relation to the different general hues with which they are decorated. Here the baſis of the dyer's art muſt ſerve as our guide. Under this relation there are four very diſtinct genera of vegetable colouring matters; the blues, the reds, the yellows and the fawn colours, with which all poſſible dyes are fabricated.

26. Amongſt the blue colours, the indigo, the paſtel, and the turnſole, preſent themſelves.

A. The indigo is prepared, in America and Africa, with a plant called *anil:* it is the *indigofera tinctoria* of Linnæus. When mature, it is chopped and put into a tub, where it is ſteeped in water, on which account the tub is called the ſteeping vat; it there ferments, and diſengages much carbonic acid and hidrogen gas; it acquires a blue colour by the progreſs of the fermentation. The plant, together with its water, is drawn off into a ſecond veſſel called the beating vat, where it is agitated, in order to ſeparate the carbonic acid from it, and cauſe the particles of the blue fecula to approach each other: ſometimes lime-water is added to it, in order to abſorb the acid more ſpeedily. When the coloured fecula is well collected, and the yellow liquor cleared, the whole is poured, turbid and agitated, into a third veſſel called a ſettling vat, where this fecula is left to depoſit itſelf, and it is drawn off while ſtill ſoft by a cock placed towards the bottom: it is then drained in canvas bags, after which it is poured in a paſte into ſquare boxes, in which it is dried in the air under ſheds, to defend it from the ſun.

Three principal ſpecies of indigo are diſtinguiſhed, according to its preparation and purity; the light, or the flower indigo *(indigo-flore)* which comes from Guatimala, which floats upon water, and is of a blue colour; the *coppery indigo*, which acquires the colour of copper when it is rubbed with a hard body; and the common *indigo*, which comes from Carolina, and is much leſs pure. But in theſe three ſpecies it is always the ſame matter which forms the blue; it differs only by the more or leſs conſiderable admixture of yellow, extraneous, and extractive matters. Even the common indigo may be purified by boiling it a long time in water. The ſulphuric acid ſoftens and diſſolves indigo, altering only the mucous and extractive ſubſtances that are mixed with it. The concentrated nitric acid burns it with a beautiful purpliſh coloured flame, and leaves a very voluminous coal: iron is found in the reſiduum. More diluted nitric acid turns the indigo brown, converts it into gum-reſin, and into vegetable acids, according to Hauſſman, who publiſhed, in 1778, a very good memoir upon this colour.

The oxigenated muriatic acid, poured upon the ſolution of indigo by the ſulphuric acid, deſtroys its colour, and changes it into a browniſh yellow. Citizen Berthollet has indicated this means for judging of the quality of indigo, according to the proportions of oxigenated muriatic acid which it requires to diſcolour it. The indigo precipitated from its ſulphuric ſolution, diſſolves in the fixed alkalis: theſe give it a green colour, which at laſt they even deſtroy.

Its analyſis by fire, and by the acids, ſhows that it contains hidrogen, azote, very little iron, and much carbon. This laſt principle appears to be more abundant in it than in any other vegetable ſubſtance, as it forms more than half its weight. It is to this ſuperabundance of carbon that Citizen Berthollet attributes all the chemical properties of indigo, and its colour which approaches to black.

A part of the oxigen contained in indigo may be taken from it by the bodies that have great avidity for it, ſuch as the green ſulphate of iron and the ſulphuret of arſenic: it then becomes green and ſoluble in the alkalis and lime; but this ſolution is decompoſed, and the indigo reſumes its blue colour and inſolubility, by the contact of the air, which reſtores to it the oxigen which it had loſt, as is ſeen in the vats of indigo which become blue at their ſurface, and in the blue which is employed in the manufacture of printed calicos. Thus its blue colour, though unalterable by the acids which only diſſolve it, is owing to a certain proportion of oxigen; when it loſes part of it, it becomes green; when it is reſtored, it paſſes again to the blue; by uniting with it a too great proportion of this principle, it is entirely burned, becomes brown or fawn-coloured, paſſing through a green colour, which proceeds from the mixture of the yellow that has been formed with the blue that is left. But this brown fawn colour of the complete combuſtion does not admit of its return any more to the beautiful blue ſtate. Hence it happens that the concentrated ſulphuric, by burning it in part, gives, when employed in dyeing, only a light or pale blue, ſuch as that which is called Saxon blue; whereas, by employing lime and different other mixtures, and eſpecially a long continued application of heat and fermentation, as in the blue vats in which woollen cloths are dyed, we obtain a rich and deep blue.

B. The *paſtel* is a blue paſte, formed by the putrefaction and reduction into a kind of compoſt of the chopped ſtalks of the *iſatis tinctoria*, or of the *iſatis Luſitanica* of Linnæus. The plant, mowed and dried quickly in the ſun, is bruiſed in a mill; it is then laid in heaps, which are ſlightly ſprinkled with ſtagnant water, and guarded againſt the ſun. The fermentation is developed in them; after a fortnight, theſe heaps are opened, they are bruiſed and mixed; round balls are then formed of them, which are dried by expoſing them to the wind and ſun. When heaped upon one another, and ſprinkled with putrified water, theſe balls become heated, exhale ammonia, dry, and are reduced into a blue which is ſold in commerce in this ſtate. It is in the departments of Gard, Aveyron, and Dordagne, that this colour is prepared in this manner. In Calvados and the Lower Seine one of an inferior quality, called woad is prepared. Aſtruc has treated the iſatis like the indigo-plant, and he ſays he has extracted from it a powder of an indigo-blue colour. Mr. Gren has deſcribed a proceſs practiſed in Germany, for changing, by fermentation, the iſatis into indigo: this proceſs, which ſucceeded, and which has ſince had the ſame ſucceſs in the experiments of Dambourney, though he was not acquainted with the German proceſs, has a great analogy with the proceſs for the real indigo. A ſtrong fermentation takes place in the ſteeping tub; much froth is formed; a blue pellicle, of a gold colour at its ſurface, preſents itſelf; the liquor is very ſubject to putrefy, and requires much attention in order to prevent it. The fecula is ſeparated from it by agitation and the addition of lime; it is dried in the ſhade. It is evident that the iſatis comports itſelf like the indigo plant, and gives an analogous blue, which however is leſs delicate and rich. Frequently it is mixed with it in vats, which are called paſtel-vats, on account of this addition. Though the ſame reſearches have not been made upon the paſtel and woad as upon indigo, what has been ſeen is ſufficient to prove that theſe two colouring matters, prepared and employed in the ſame manner, are of a very ſimilar nature.

C. The ſame is not the caſe with the bad blue colour known by the name of *turnſole*, which is fabricated at Grand-Gallargues in *(ci-devant)* Languedoc, by impregnating rags with the juice of the *croton tinctorium*. Theſe rags, which are called *tourneſol* in rags, being exported into Holland, are, as it appears, diſcoloured and reduced into paſte with ſoda; of this the cakes of turnſole are formed, in which I have conſtantly found ſoda, which gives them the violet-blue colour they are known to poſſeſs, and which appear to me to be the red, tinged with blue, or rendered violet by the preſence of the alkali. This tranſient colour, which is extremely alterable, and becomes red by the contact of the weakeſt acids, as well as by many other bodies, is very different from the fecula of indigo; it ſerves only to colour common paper, and produces upon a multitude of tinges or ſtains on piece goods which are quickly deſtroyed by the air and the ſun.

27. The dyeing-reds, that is to ſay the red colouring matters which may be extracted from vegetables, and which are employed for dyeing this colour, are much more numerous than the blues properly ſo called. In this genus are reckoned madder, archil, carthamus, Brazil-wood, and Campeachy or log-wood.

A. Madder, *rubia tinctorum* of Linnæus, furniſhes by its roots, when well cleaned, dried, pounded, and ſifted, a powder of a fawn or reddiſh yellow colour, from which only a part of the colour is extracted with boiling water, but the whole with water ſharpened with alkali. It is therefore of the nature of the oxigenated extractives; it is alſo ſoluble in alcohol. The alkali gives to this dye a violet colour, the ſalts a fine red colour. It is employed only with mordants. The difference of the piece goods has much influence upon that of the dyes which are obtained from it. Dambourney, Beckmann, Wath, and Wogler, have made many intereſting experiments upon the employment of this material. Scheffer, Guhliche, Poerner, Citizens Berthollet and Chaptal have alſo examined it with attention. It is with this material that the famous red cotton of Adrianople is prepared. It is now manufactured in France of ſtill greater beauty and luſtre. It appears that madder, like the carthamus, contains two different matters,

ters, the one red and the other fawn-coloured. Its decoction affords inſoluble pellicles, which depoſit themſelves like thoſe which are formed on the extracts. It has the property of colouring the bones of animals to which it is given mixed with their nouriſhment. As whatever belongs to its properties and uſes intereſts only the art of dyeing, and preſents but few general reſults to the ſcience, I ſhall not dilate more amply upon this ſubject. Some modern chemiſts ſuſpect that it contains an acid.

B. Archil is a kind of violet-red paſte, prepared in the Canaries and at Cape Verd with the *lichen roccella*, and in the departments of Puy-de-Dome and of Cantal, with the *lichen parellus;* the firſt is called *orſeille d'herbe*, and the ſecond *orſeille de terre*. This laſt is very much inferior in quality to the firſt. The archil is obtained by macerating theſe lichens, previouſly dried and pulverized with urine and lime. The art of preparing it has not yet been deſcribed with accuracy, and it conſiſts in ſome particular manipulations which appear to be eſſential. Formerly it was prepared very good at Florence: Micheli has indicated the mode of its preparation, and it is after him that Hellot reports it. Archil gives its colour to water, to the alkalis, and to alcohol. This laſt tincture is eſpecially uſed for thermometers; its colour diſappears in a vacuum, and re-appears in the air. The infuſion of archil is violet; acids turn it red; alum forms in it a precipitate of a brown-red colour; the muriate of tin a reddiſh precipitate. When applied cold to marble, this infuſion gives it a fine violet colour, which remains, according to Dufay, for ſeveral years without alteration in the air. Dyeing with the archil is performed by immerſing the ſtuffs in its ſimple infuſion. But this dye is of little durability; it ought only to be employed for heightening the tints and giving greater luſtre to other colours; the dyers, from the beauty of its colour, frequently make a fraudulent uſe of this ſubſtance; the ſolution of tin cauſes it to imitate ſcarlet, and renders it as ſolid and durable as it is capable.

C. The flower of the carthamus, or baſtard ſaffron, *cartamas tinctorius* of Linnæus, when deprived of its fawn or yellow colour by water, gives, with the aid of the alkalis, another red or very deep yellow colour. This colour may be precipitated by an acid which renders it yellow as well as the liquor. The flower muſt be well waſhed, or even prepared with water, before it is finally dried, in order to deprive it of its firſt colouring part, and to preſerve the ſecond pure. This yellow may however be employed with utility, according to Beckman, for dyeing cloths: he even aſſerts that carthamus contains more of it than the yellow wood. The red colour is extracted by the alkalis, and eſpecially by ſoda, and it is precipitated upon the ſtuffs by the acids, particularly that of the lemon; the acid of the berries of the ſervicetree may be ſubſtituted inſtead of lemon-juice, which is very dear. It is with the red fecula of the carthamus thus extracted, and dried upon plates, that the rouge uſed by ladies is prepared, by mixing it with talc or Briançon chalk, ſcraped with the ſtalks of theve-graſs. The carthamus is cultivated in the large way in Spain, in Egypt, in the Levant, and in Thuringia. It would be a very good acquiſition for France to make. Its ſeed affords a good oil, and fattens birds; its ſtalks feed ſheep and graſs in the winter; and its flower is particularly uſeful for dyeing ſilk red, poppy, orange, cherry, roſe, and fleſh-colour.

D. Brazil wood, called alſo Fernambouc, wood of St. Martha, of Japan, of Sapan, according to the places from which it is brought, is cultivated in the Iſle de France; that of the Antilles is called *breſillet*, and is the leaſt eſteemed: this is one of the matters moſt uſed in dyeing. Its botanical name is *Cæſalpina criſta, Cæs. ſappan, Cæs. veſicaria;* theſe are the three ſpecies of trees which afford the three varieties that have been indicated: the veſicaria affords the breſillet. This wood becomes red in the air; it is of a ſaccharine taſte; the heavieſt is the beſt. Boiling water, alcohol, and ammonia, take from it all its colour; it afterwards appears black. Thoſe ſolutions give a red colour to marble, which paſſes to the violet, and becomes fixed in the chocolatebrown. The acids precipitate from its decoction, flakes of a fawn-red colour. The alkalis render it crimſon or dark violet; alum forms in it a crimſon-red precipitate, and a ſecond is obtained from it by adding alkali to the liquor. The metallic ſolutions alſo produce coloured precipitates; that of the ſuper-oxigenated muriate of tin gives one of a beautiful roſe colour. The decoction of this wood, which is called Brazil *juice* in the workſhops, is more valuable when it has been kept for ſome time than when freſh. Dyeing is performed with this juice, after having previouſly impregnated the ſtuffs with alum and with tartar. It affords bright reds, which reſiſt the effects of the air pretty well, but are leſs ſolid than the madder-colours. An acid added to the liquor, before the ſtuffs are immerſed in it, communicates to them a very ſolid fawn-yellow colour. Alumine and oxide of tin give this colour much more fixity than it naturally has. The aſtringent principle alſo augments its ſolidity. Alkalis are employed for producing violets with it, but they have very little durability. It is uſeful to pulverize this wood, becauſe much more colour can then be extracted from it, and that much more quickly and eaſily. Lakes much employed for paper-ſtaining are prepared from it with alum, ſtarch, and the alkalis, which precipitate its decoction.

E. Campeachy or log-wood, *hæmatoxytum Campechianum* of Linnæus, grows in abundance in Jamaica, of which it alſo bears the name: it is likewiſe abundant in St. Cruz, Martinico, and Grenada. This wood differs from the Brazil only by the dyes which it affords: its colouring part is of the ſame nature, is rendered lighter and yellow by the acids, darker and violet by the alkalis, becomes brown and black in the air, is extremely ſoluble in water, cannot be fixed alone upon the ſtuffs, but requires the action of mordants, is rendered ſolid by the metallic ſolutions, alum and tartar: it is, like the Brazil wood, an extractive colour, ſlowly combuſtible and diſ-hidrogenated by the contact of the air. It is eſpecially employed for violet dyes, and for giving a velvet appearance and luſtre to the blacks and greys; it is uſed in the dyeing of ſilk to produce a great number of dyes, from the lilac to the dark violet, by means of the ſolution of tin. Dark coloured and conſiderably ſolid lakes are alſo prepared with its decoction.

28. Though the yellow colours are extremely abundant at the ſurface of vegetables, and though theſe eſpecially are the moſt common and moſt durable ornament of their flowers, yet the number of the plants which afford ſoluble yellows applicable to dyeing, is not ſo conſiderable as the firſt aſpect might ſeem to indicate. Thoſe particularly known in this genus are weld, yellow wood, annatto, ſaw-wort, dyer's-weed, curcuma, Venus's ſumac, French-berries (Graine d'Avignon),

d'Avignon), and quercitron: there are, however, a conſiderable number of others; but it is ſufficient to indicate the ſpecies that are the moſt employed, and the moſt common.

A. Weld or woald, *reſeda luteola* of Linnæus. The ſtalks of this ripe plant, when dried and tied in bundles, give by decoction in water a yellow colour inclining to the brown; when diluted with water, it has a green tinge. The acids render it paler, and the alkalis darker; alum forms in it a yellowiſh precipitate, and the liquor preſerves a lemon colour. The ſolution of tin produces in it an abundant precipitate, of a light yellow colour; the liquor remains turbid, but little coloured. This ſubſtance is employed as a yellow dye for linen, ſilk, and cotton; but it will not ſucceed, unleſs alum and tartar be employed as mordants. The dies vary according to the proportion of the mordants and their nature. The uſe of this colouring ſubſtance is called *welding*. Alkalis and lime are added to it, and madder or annatto is mixed with it, in order to obtain different orange and jonquil caſts in the dyeing of the goods called calico printing. The mordant compoſed of alum and of acetite of lead is employed.

B. Yellow wood comes from a large tree of the Antilles, which grows eſpecially at Tobago: it is a ſpecies of mulberry, *morus tinctoria.*

It is yellow, with orange-coloured veins: its well-charged decoction in water is of a deep red-yellow colour, which becomes of an orange yellow. The acids precipitate from it a light fecula of a greeniſh-yellow colour, which the alkalis re-diſſolve, giving it a reddiſh colour. Moſt of the metallic ſalts and alum precipitate it; the laſt in a yellow ſtate and little abundant, the muriate of tin of a beautiful yellow colour, and in great abundance; the acetite of lead, abundantly of an orange-yellow; the ſulphate of iron in a yellow which turns brown. This wood, reduced into ſplinters or chips, is employed for dyeing by keeping it in a ſack in the midſt of the bath: its decoction gives to the goods, without any other preparation and without mordant, a yellow with a little of a browniſh caſt, dull, ſufficiently permanent in the air; whilſt weld, alſo without a mordant, communicates to it a pale yellow of little ſtability. The mordants, alum, tartar, and the muriate of tin, fix it, and render its colour lighter; the muriate of ſoda and the ſulphate of lime render it darker; it affords the ſame gradations of tinges as weld. This wood has lately become known and diffuſed in Europe; it is of a moderate price; it is one of the moſt uſeful ingredients in dyeing, and its colour is ſufficiently ſolid.

C. Annatto is a dry and hard paſte, browniſh externally, and red internally, in lumps of about a kilogramme, covered with reed-leaves. It is prepared in America with the ſeeds of the *urucu*, a tree which Linnæus calls *Bixa Orellana*, which are bruiſed in water, and then left to macerate and ferment. The Americans, according to Labat, prepare a finer and more ſolid colour from it, by cruſhing and ſtrongly kneading thoſe ſeeds in their hands impregnated with oil, detaching the liniment which is thus formed, and drying it in the ſun. The decoction of annatto in water has a ſtrong and very diſtinguiſhable ſmell, and a diſagreeable taſte. Its colour is a yellowiſh red. It diſſolves better in an alkali, and its colour is then a lighter orange yellow. Alcohol alſo diſſolves it very well, and it enters into thoſe varniſhes that have a ſlight orange tinge. The alkalis precipitate its alkaline ſolution in an orange coloured ſtate, as well as alum, which forms in it an abundant lake of a deep orange colour. The ſuper-oxigenated muriate of tin produces in it a precipitate of a citron-yellow colour, which is depoſited ſlowly. It is treated by the alkalis for the yellow dyes; but affords only a fugacious colour upon wool. It is much more uſeful and much more employed for ſilk, which is merely kept more or leſs immerſed in it, after it has been boiled with a fifth of its weight of ſoap: in this manner an aurora colour is given to it. By afterwards impregnating it with vinegar or alum, it becomes orange-coloured. It is ſometimes employed cold; it is alſo uſed for cotton, which is dyed orange with it, by the aid of tartar, as a mordant.

D. Saw-wort, *ſerratula tinctoria* of Linnæus, gives without mordant a greeniſh-yellow colour of no ſolidity; alum fixes it, and modifies the colour into a ſolid and agreeable yellow. The ſulphate of lime gives, according to Poerner, a darker colour; the muriate of tin enlivens it very much, according to Scheffer.

E. Dyer's broom, *geniſta tinctoria* of Linnæus, a plant very common in dry and mountainous ſituations, gives a yellow which is much leſs beautiful than that of weld and ſaw-wort; it acquires a ſufficient degree of ſolidity by alum, tartar, and the ſulphate of lime.

F. Curcuma, or *terra merita, curcuma longa* of Linnæus, contains in its root which is brought to us from the Eaſt Indies, but which grows alſo in ſome of the Antilles, an orange-yellow colouring part, which is very bright and beautiful, and in great abundance, but of little permanency and very fugitive. Water extracts it very eaſily; even the mordants give it only an imperfect fixity. The muriates of ſoda and ammonia are thoſe which ſucceed the beſt, but they give it a brown caſt: it can only be employed in powder. It is uſed for communicating a brilliant golden tinge to the weld yellows, and an orange to ſcarlet; but theſe ſhades quickly diſappear in the air. The curcuma is uſeful in chemiſtry for indicating the preſence of alkaline matters which cauſe it to paſs into a purpliſh fawn or brown colour with great energy.

Paper is coloured with glue, mixed with a decoction of this root.

G. Venus's ſumac, *fuſtet, rhus cotinus* of Linnæus, is a wood of an orange and green colour, chatoyant, which is employed in chips for dyeing, and which gives a fine orange colour, but not ſolid. It is employed only in order to obtain orange-yellow tinges with other colouring matters, which render its own more fixed and durable. It is eſpecially combined with cochineal for obtaining jonquil, gold, and chamois colours.

H. The French-berries (*Graine d'Avignon*) are the berry of the *Rhamnus infectorious* of Linnæus; it gives a ſufficiently beautiful yellow, but of no ſolidity. It is employed only with mordants and treated like weld. A ſpecies of brilliant yellow lake is prepared with it, which is employed in painting, for paper and for wood that is to be ſtained yellow.

I. Quercitron is the bark of a yellow oak of New-England, of which Mr. Bancroft has given an account, and propoſed to ſubſtitute it inſtead of weld, eſpecially for calico-printing; it is much more rich in colour than this plant, and one part of it may ſupply the place of ten. It is merely infuſed in hot water; its yellow colour is fixed upon wool with alum and muriate of tin; the latter gives it a great degree of luſtre. The Engliſh manufacturers of printed goods prefer this bark to weld, as being more economical and permitting the grounds to be better bleached. Dambourney ſays that the advantages indicated by Mr. Bancroft are obtained by previouſly treating the wool with muriate of tin: it is a very good acquiſition for the art of dyeing.

29. The vegetable colouring parts that give the fawn colour to ſtuffs are extremely numerous; they are in general all the aſtringent matters: employed alone and without mordants, they depoſit their colouring part upon the goods. The principal ſpecies of this genus are the outer ſhell of the walnut, the root of the walnut, ſumac, the bark of the alder, ſanders, ſoot, and eſpecially the nut-gall. All the barks contain more or leſs of this colouring principle, of the nature of the oxigenated extractive; accordingly in the numerous experiments deſcribed by the laborious and eſtimable Dambourney, *upon the ſolid dyes of indigenous vegetables*, they were always the colours placed between the yellow and the brown, carmelites, olive, cinnamon, cheſnut colours, which he obtained, either by theſe vegetable matters employed alone, or with different mordants.

A. The outer ſhell of the walnut, or the kind of pulp which covers the kernel, is white and grows black in the air, as every one knows. This blackneſs adheres to the fingers, and cannot be removed without difficulty; if immerſed in weak oxigenated muriatic acid, it immediately becomes brown. Its filtrated decoction becomes brown in the air, and gives by evaporation inſoluble pellicles, apparently reſinous and almoſt black; this is the colouring matter altered by a ſlight combuſtion, and almoſt reduced to charcoal; alcohol precipitates the ſolution; the muriatic acid blackens it; the muriate of tin forms with it an abundant precipitate, of an aſh-fawn colour; alum produces ſcarcely any; ſulphate of iron renders it almoſt black. The outer ſhell of the walnut has a ſtrong action upon iron; it diſſolves it and forms ink; its colouring part has a great diſpoſition to unite with wool, and gives it a nut or fawn colour, to the ſolidity of which the mordants add little. It is an excellent colouring matter; it affords agreeable and very ſolid colours; it preſerves the ſoftneſs of the wool and requires no mordant. At the Gobelins, one of the fineſt dyeing eſtabliſhments that exiſts, the outer ſhells of freſh walnuts are collected in tubs; they are covered with water, and kept for one or two years before they are uſed; and it is remarked that they then yield more colouring matter; the mordants or the metallic oxides and ſolutions vary its tinge.

B. The root of the walnut and eſpecially its bark have preſented the ſame properties to Citizen Berthollet; they give the ſame colours; it is only neceſſary to augment the quantity, and to employ them in chips encloſed in a ſack, like all the hard bodies which may attach themſelves to the ſtuffs and tear them. They have the inconvenience of frequently giving unequal colours, like all the ſolid matters whoſe colouring part does not diſtribute itſelf equally in the liquor; this may be avoided by a proper management of the fire.

C. Sumac, *rhus coriaria* of Linnæus, is cultivated abundantly in Spain, in Portugal, and in the South of France, for the purpoſes of dyeing. Its ſhoots are every year cut to the root; they are dried and ground for dyeing and tanning. Its infuſion, which is of a ſomewhat greeniſh fawn colour, ſoon becomes brown in the air; the acids turn it yellow; alum renders it turbid; the acetite of lead forms in it an abundant yellowiſh precipitate which becomes brown. Sumac, like the nut-gall, decompoſes the nitrate of ſilver, and reduces its metal by the contact of light: of all the aſtringents it is that of which the properties approach neareſt to thoſe of the nut-gall; but its black precipitate with the ſolutions of iron is leſs abundant than that of the gall. It may be ſubſtituted in place of it by uſing a double proportion: it gives by itſelf a fawn colour inclining to a green. The acetite of alumine, a common mordant amongſt the calico-printers, cauſes it to aſſume a beautiful and ſolid yellow; its colour is ſo fixed that the cloth cannot be bleached in the field; on which account it is employed only for cloths with coloured grounds, the deſigns and colours of which are varied by different means.

D. The bark of the alder, *betula alnus* or *alba*, gives a light fawn-coloured decoction, which ſoon becomes brown and turbid by the contact of the air and the abſorption of oxigen, like all the aſtringents. Alum forms in it an abundant yellow precipitate; the muriate of tin a precipitate equally abundant and of a lighter yellow. The ferruginous ſalts convert it into ink; it diſſolves the oxide of this metal very well: it is alſo employed for the black vats in the dyeing of thread.

E. Red Sanders, the only one which is uſed in dyeing, is a ſolid, compact, heavy wood, which becomes brown by expoſure to the air: it is brought from the coaſt of Coromandel. Its fine powder gives to boiling water a fawn-brown colour, inclining to red; it diſſolves ill by itſelf, but very well with the ſkin of the walnut, ſumac, and nut-galls: its colour is ſolid, and uſefully modifies that of theſe other matters. Vogler having found that alcohol diluted with water diſſolved the colouring matter of ſanders better than water does, employed this ſolution for dyeing ſamples of wool, cotton, and linen, previouſly impregnated with ſolution of tin, waſhed and dried: they acquired a poppy red; alum cauſed them to aſſume a fine ſcarlet colour; the ſulphate of copper a light crimſon; the ſulphate of iron a deep violet. The alcoholic tincture acts cold; after it has been mixed with water it requires a ſlight ebullition.

F. Soot gives to wool a brown or fawn colour, more or leſs deep, but which is periſhable, and attaches itſelf only to its ſurface without combining with it; it hardens it, and leaves a bad ſmell; it is however employed for giving a brown tinge to ſome colours, and for obtaining certain caſts which could not be obtained with other matters but with great difficulty. What is of importance here with reſpect to the hiſtory of the vegetable colouring matters, is that it may throw ſome light upon the nature of theſe matters, and prove that the oily ſubſtance of which ſoot is in part formed, is one of the matters which approach the moſt to the nature of theſe colouring parts.

G. But none of the matters which give a fawn-coloured dye, of which we have been ſpeaking, is comparable to the nut-gall with reſpect to its influence upon colorations; it forms the firſt and the ſtrongeſt of theſe dyes. It is known that the nut-gall is an excreſcence formed upon the leaves, the petiolæ and the ſmall branches of the quercus robur, when punctured by an inſect. The beſt nut-galls are brought from the Levant; thoſe of France are not uſed. The taſte of the nut-gall is acrid, acerb and extremely aſtringent; it may be employed for tanning ſkins, though in this reſpect its operation is feeble. Its nature, properties and effects have been ſucceſſively examined by Macquer, Lewis, Monnet, the chemiſts of Dijon, Scheele, Citizens Berthollet, Deyeux, and Mr. Prouſt. It was firſt ranked at the head of the aſtringents, and its effect upon iron and its ſolutions which it blackens, was aſcribed to its aſtringent property, which was believed to exiſt of the ſame nature in the other acerb vegetables. Its principle which blackens iron, has been found to be ſublimed by diſtillation, to paſs into its different products, to communicate itſelf to the acids and the alkalis with which it was treated, and to ſeize immediately upon iron in the ſtate of metal. Scheele afterwards extracted from it a particular acid, which has already been examined under the name of *gallic acid.* It has ſince been found that this acid can be obtained by ſublimation, that it precipitates all the metallic ſolutions, that it approaches their oxides to the ſtate of metals, that it alſo blackens iron. Moreover Citizen Berthollet has ſhown that this acid is not the only aſtringent ſubſtance or the principle of this property; that every aſtringent acts in a peculiar manner upon the ſolutions of iron; that ſome precipitate it in a brown ſtate, others dark green, others purple or violet, and others blackiſh-blue; that the nut-gall leaves a large quantity of charcoal after its analyſis; that this ſuper-abundance of charcoal contributes much to the black coloration, by remaining alone and ſolid after the combuſtion of the hidrogen. Mr. Prouſt has ſince remarked that the aſtringent part of the nut-gall effectually blackens only the highly oxigenated or red oxide of iron; that it does not act upon the too little oxided ſalts of iron; that much is gained in the preparation of black colours by employing the red ſulphate of iron. Such are the baſes upon which the numerous advantages of the nut-gall in dyeing are eſtabliſhed.

We ſhall ſee, in one of the ſubſequent articles, that the nut-gall contains along with the gallic acid, beſides extractive and mucilage, a certain proportion of a particular principle called tanin, which may be ſeparated from theſe different matters diſſolved with it in a decoction of nut-galls, by the acids, the alkalis and the ſalts.

F. *Uſes.*

30. The principal uſe of the vegetable colouring matters is, as we have ſeen, to ſerve in dyeing and ſometimes in painting, after they have been extracted and prepared into ſolid matters or lakes. The art of dyeing is one of the moſt beautiful that exiſts; it is one of thoſe in which human induſtry ſhows itſelf at the higheſt degree of perfection, and the products of which imitate, if they do not ſurpaſs, thoſe of nature. As the purple of Tyre rendered that city illuſtrious in antiquity, how greatly ſuperior are the moderns in this reſpect; to all that the ancients have produced, the moſt grand and beautiful, both in the multiplicity and variety of the colours, in their ſolidity, and in the refinements and number of the proceſſes which they employ, as well as the very common uſe of all the dyed ſtuffs, which with the Romans were only the marks of the conſular or patrician dignities, or the diſtinction of the rich alone, whilſt with us

nothing is more common than the moſt brilliant and moſt durable colours.

ARTICLE XX.

Of the ſeventeenth of the immediate materials of Vegetables; of the Vegetable Albumen.

1. NO author on chemiſtry has yet enumerated amongſt the principles or immediate materials of vegetables the ſubſtance which I call vegetable albumen, though for more than forty years the chemiſts, eſpecially thoſe of the ſchool of Rouelle, have found ſeveral vegetable matters, and even entire plants that had the characters of animal ſubſtances. The reader will call to mind what I have ſaid above, relative to this ſubject, concerning the extractive and glutinous principles. I have alſo ſhown in the preceding articles that moſt of the vegetable colouring ſubſtances yield ammonia by analyſis, that they contain azote, and that it is probably by this analogy of their primitive nature that they have ſo much attraction for the animal matters.

2. In order that it may be well comprehended what I underſtand by the vegetable albumen, I muſt mention that the name of albumen is particularly applied in the body of animals, to a liquid, ropy, and viſcous, of an inſipid taſte, ſoluble in cold water, concreſcible and

ſolidifiable by heat, abandoning the water, and ſeparating from it in the form of flakes when it is heated, turning the ſyrup of violets green, ſoluble by the alkalis, and eſpecially by ammonia, putrefying without paſſing through the acid ſtate, affording azotic gas by the nitric acid before paſſing into the ſtate of oxalic acid. If there be found in the vegetable analyſis a matter which combines theſe properties, it is evident that it will merit and ought to bear the name of *albumen*, derived from *albumen*, white of egg, which combines them in an eminent degree.

3. The firſt obſervations which led me to ſuſpect in 1787, and ſoon afterwards to determine with preciſion the preſence of an albuminous matter in vegetables, were the phenomena that were preſented to me by the defecation of the juices of the moſt coloured green plants. In order to defecate the juices of the cochlearia, of creſs, of beccabunga, it is known that it is ſufficient to plunge the bottles which contain them into hot water, between ſixty and eighty degrees of Reaumur's thermometer, and even a little below this temperature. The green fecula which impairs its tranſparence, ſoon concretes and collects in ſmall ſolid flakes, almoſt round, which float at the ſurface of the vegetable liquids, or depoſit themſelves at the bottom, and are very eaſily ſeparated by mere filtration. I conceived then that this kind of defecation employed in order not to alter the juices and ſepa-

rate from them the moſt volatile part which characterizes them, could depend only upon the property of being coagulated by the action of the caloric, and that as this property belongs excluſively to the albumen, it indicated, in an unequivocal manner, its preſence in the antiſcorbutic plants.

4. I have confirmed the firſt idea by direct experiments. As it was impoſſible to conſider the feculent matter of theſe juices, thus coagulated by heat, as pure albumine, on account of its green colour, I endeavoured to ſeparate the colouring part from it, in which I ſucceeded by the following proceſs. Juice of young creſs, filtrated cold through a piece of white paper without ſize, left its groſs fecula upon the filtre, and paſſed clear, but coloured with a beautiful green: expoſed to the air in a flat veſſel, at a temperature of the atmoſphere of 23 degrees of Reaumur, it became turbid in two hours and changed its colour; a fecula of a deep green, much finer than the firſt, ſwam like a ſort of flakey powder in the midſt of this juice; filtrated a ſecond time, this fecula remained upon the paper, and the juice was now only of a very pale green colour. I then plunged it in a bath, the water of which was boiling; in a few minutes it became turbid, and there was ſeparated from it a great quantity of ſmall whitiſh clots. Another portion of the ſame juice, left in the air, preſented to me at the end of two days, grey flakes, ſimilar to the preceding. The ſulphuric

acid ſeparated from a third portion of the diſcoloured juice concrete clots of the ſame matter. It is evident that Rouelle took this albumen of the juices of plants for glutinous matter.

5. Theſe flakes, whether depoſited ſpontaneouſly in the air, ſeparated by fire or by an acid, if carefully waſhed in much cold diſtilled water, preſented to me in their examination moſt of the properties of albumen in part concrete. The alkalis diſſolved them quickly and eaſily; boiling water did not attack them, and gave them greater ſolidity than they had at firſt; they gave a ſenſible green tinge to paper dyed with mallow-flowers; diſtilled, they afforded ammonia; macerated in a little water, they became inflated, ſoftened, exhaled a fetid ammoniacal ſmell, and exhibited all the ſigns of the ſtrongeſt putrefaction. It undoubtedly proceeds from this albumen that the cruciferous plants become ſo quickly altered, and diffuſe ſo infectious an odour during their corruption. A portion of this albuminous portion of the creſs, expoſed to a dry and hot air, after having been well dried by preſſure in fine paper without ſize, acquired a ſort of ductility and tranſparency analogous to that of glue: in a word, it comported itſelf abſolutely like the animal albumen, from which it differed only by its inferior tenacity and viſcoſity.

6. The juices of cabbage, of cochlearia and of beccabunga, gave by the action of heat an albuminous concretion, perfectly ſimilar to that

of the creſs. The root of patience preſented to me a very remarkable fact relative to this principle. I wiſhed to prepare the extract of patience with young and ſmall roots of this plant; I found theſe roots ſo much charged with juice, that I had them reduced into pulp and preſſed; the expreſſed juice was without colour or bitter taſte; by evaporating it, I obtained no extract, but there were ſeparated from it many ſmall concrete and white flakes, much reſembling thoſe that are depoſited from whey during its clarification. A part of theſe flakes was precipitated to the bottom of the liquor, another raiſed itſelf in a ſcum to the ſurface of the juice. On examining them, I found them to poſſeſs all the properties of albumen.

7. Another circumſtance in which I have likewiſe diſcovered the preſence of the albumen in the vegetable matters, is the analyſis of the water of the lixiviation of flour; a lixiviation by which the gluten is left pure, the amilaceous fecula is precipitated in a white powder to the bottom of the water, and a mucoſo-ſaccharine matter diſſolves in this liquid. By evaporating this water, when very clear, and without any extraneous ſubſtance, there are ſeparated from it white flakes of a concrete ſubſtance, which collect alſo in a white ſcum at the ſurface of the liquor. Theſe flakes, well ſeparated and waſhed, preſented to me all the characters of albumen. Thus there are two animal ſubſtances in flour, the gluten and the albumen.

8. I have

8. I have found traces of albumen in all the green feculæ, or rather in all the vegetable juices charged with a large quantity of this fecula, and in general in all the conſiderably green plants; the young woods, the annual ſhoots; I have not been able to extract any from perfectly formed wood, though the ammoniacal fetidity which it exhales when it is macerated in water, indicates that it is preſent in it, but in a concrete and inſoluble ſtate. Neither has any vegetable acid preſented to me the ſlighteſt trace of it, though all the juices of this nature are ſurcharged with gummy or gelatinous mucilage, which is ſpeedily depoſited from them. It may be ſaid that here, as in the treatment of animal matters, the albumen is diſſolved and changed into gelatin by the acids.

9. Since I publiſhed my firſt reſearches upon this ſubject, Citizens Deyeux and Vauquelin have deſcribed the properties which they have found in ſeveral of the ſaps of trees; and from the account and compariſon of their experiments, it is not difficult to perceive that they have found albumen in theſe liquids. It appears even that it is this portion of albumen which Citizen Deyeux took for gluten, with which it has very conſiderable analogies, both in its chemical characters and in its intimate nature.

ARTICLE XXI.

Of the Eighteenth of the immediate Materials of Vegetables; of the Ligneous Matter.

1. IT is not long ſince chemiſts have begun to conſider the ligneous matter as a particular principle of vegetables; they formerly believed it to be a kind of earth, and they treated, or rather they neglected it, as ſuch in all their experiments. Thus after having exhauſted the ſolid vegetable matters by decoction in water, and by the action of alcohol, what remained untouched and inſoluble after this mode of analyſis was conſidered as an earthy ſubſtance, a *caput mortuum* which they entirely neglected. However, its combuſtible property ought to have drawn them from this notion, and induced them to examine this particular ſubſtance. Some, and I myſelf was of this opinion in the firſt periods of my inquiries, had begun to diſtinguiſh it as a body different from earth, and to compare it with the fecula; but new reſearches ſoon changed my opinion in this reſpect, and I ſhall now give an account of that which they have led me to adopt, by indicating the reſults of my experiments, which will preſent the diſtinctive properties of the ligneous ſubſtance.

2. After having exhauſted a ſolid vegetable matter, eſpecially wood, bark, or a woody root,

of all that it contains which is ſoluble in the re-agents which act only as ſolvents, and do not alter the intimate nature of the portion not diſſolved; for example, after having boiled this matter in large quantities of water, till it paſſes off without colour or taſte, and without containing any thing, there remains a pulverulent, or fibrous, or lamellated ſubſtance, more or leſs coloured, ſufficiently ponderous, inſipid and inodorous, inſoluble, and which, on account of theſe properties, was formerly conſidered as an earth. Boiling water having no action upon this body, and being incapable either of ſoftening or diſſolving it, I have thought that it conſiderably differs from the amilaceous fecula, to which I had formerly compared it, and I have conſidered it as the vegetable ſkeleton.

3. This matter, which I call the ligneous matter, or the body, preſents properties which diſtinguiſh it from all other vegetable ſubſtances, and from all the immediate materials which are extracted from plants. When it is heated in contact with the air it becomes black without melting or ſwelling: it exhales thick fumes of an acrid, pungent and peculiar ſmell, in part ammoniacal; it leaves a coal which retains its form, and from which are extracted, after it has been reduced to aſhes, ſaline matters, eſpecially a little pot-aſh, ſulphate of pot-aſh, ſulphate of lime and phoſphate of lime. When it is diſtilled in the retort, it affords water, a particular acid known by the name

of *pyroligneous acid*, oil, in part thick, concrete and empyreumatic; carbonated hidrogen gas and carbonic acid, and a portion of ammonia combined with pyroligneous acid. The coal which remains after this diſtillation has conſtantly the form of the wood, or of the fragments of wood that have been ſubjected to diſtillation, and it comports itſelf like that which is obtained by heating the ligneous ſubſtance in contact with the air. The ammonia, one of the conſtant products of the ligneous ſubſtance, proves that this ſolid matter contains azote among its primitive principles, and I have found that it afforded about one hundredth of its weight. I have no doubt but that ſome woods may be met with which will yield more of it.

4. One of the characters which moſt eſſentially diſtinguiſh the ligneous ſubſtances conſiſts in the property which it has of yielding, by the action of fire, a particular acid, different from theſe that are obtained in the analyſis of any of the other immediate materials of vegetables, and which on that account has been called in the methodical nomenclature the *pyroligneous acid.* I have only indicated it in the ſyſtematic enumeration of the acids, and I muſt here give an account of its properties, as being the conſtant product of the action of fire upon the vegetable matter which I examine in the preſent article. Boerhaave firſt diſtinguiſhed it by the name of *acid ſpirit of wood,* and he has remarked that the hard woods, eſpecially that of Guaiacum,

furniſh the moſt of it. Mr. Goettling has given a particular examination of it in 1779, in Crell's Chemical Annals, and the Academicians of Dijon have ſucceſsfully repeated his experiments.

5. All the woods, of whatever kind they may be, yield this acid by diſtillation ; nothing more is requiſite, in order to obtain it, than to diſtil this body in chips in a retort of iron or ſtone-ware ; beech, oak, or birch are eſpecially choſen for this purpoſe. A reddiſh, very odorous, and very pungent liquor is obtained ; the diſtillation is ſtopped at the moment when the oil, which would colour and alter this product, begins to paſs ; or elſe it is rectified by a ſecond diſtillation with a gentle and well-managed fire ; in this manner as much as one third of acid liquor is obtained from the wood. When this acid is pure, it is ſimply of an amber colour, without being either oily or empyreumatic ; its ſpecific gravity is to that of diſtilled water, as 49 to 48.

6. In the ancient methods of diſtilling wood, when their different products were collected and mixed, or were ſuffered to confound themſelves together in the receivers in which they were collected, the acid ſpirit was ſeparated from them by a funnel ; firſt there paſſed a ſmall quantity of heavy oil which occupied the tube of the veſſel ; afterwards followed the acid liquor of a more or leſs deep red colour ; then another portion of oil which had remained at the ſurface.

In this manner could be ſeparated, by mere mechanical means, three different products in three different veſſels, by receiving them ſeparately according to their ſpecific gravity. The acid liquor thus obtained was very highly coloured and impure; it contained a portion of oil in ſolution, which was gradually precipitated from it in brown and heavy drops; it diffuſed an acrid empyreumatic ſmell, together with that peculiar to it. It may eaſily be rectified by diſtilling it with a lamp or ſand-heat in a retort; by this means it is ſeparated from the empyreumatic oil which alters it; it is obtained in a liquid of an amber-yellow colour, having no longer the fetid ſmell of the firſt product.

7. This acid, thus rectified and purified, or obtained from its firſt diſtillation made with the precautions before indicated, has a lively ſmell, but which is not ſtrongly empyreumatic, a very acid and ſlightly acrid taſte; it ſtrongly reddens the blue colours, and very quickly reſtores the yellow colour of the curcuma when it has become purple by the action of the alkalis. When heated in a retort, it is decompoſed and burned, like all the vegetable ſubſtances that are treated with a ſtrong fire; it affords water, carbonic acid, and leaves a ſmall quantity of coal in the retort. When gently heated, it is volatilized without decompoſition; its volatility does not appear to be ſuperior to that of water. The pyroligneous acid has a pungent and manifeſtly acid ſmell, which is peculiar to

it, and by which it may eaſily be diſtinguiſhed from every other odorous matter.

8. Combined with the earths and alkalis, it forms particular ſalts, different from all others that are known. Mr. Goettling has employed pyrolignite of pot-aſh treated by the ſulphuric acid, in order to extract the pure pyroligneous acid. This ſalt became much heated with the ſulphuric acid; and the pyroligneous acid thus ſeparated had loſt its empyreumatic odour, and acquired an alliaceous one. Citizen Eloy Bourſier, of Clairvaux, has begun to examine the elective attractions of this acid for the earthy and alkaline baſes. Lime and barites attract it more than the alkalis. Lime ſeems to hold the firſt rank in theſe attractions; magneſia is before ammonia. This order, if well confirmed, would be ſufficient to diſtinguiſh this acid from all others. For the reſt, the alkaline and earthy pyrolignites are not yet known with ſufficient accuracy, to enable us to preſent a hiſtory of them. It appears alſo that the pyroligneous acid acts upon the metals and their oxides after the manner of the acetous acid, and that it might be employed in ſome of the arts in the ſame manner as the latter. It exerts a colouring action upon the vegetable and animal ſubſtances; it colours wood red and brown.*

9. To this diſtinguiſhing character of the ligneous matter, of furniſhing a particular acid

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* Reſpecting this acid, which has ſince been aſcertained to be the acetous, ſee the Tranſlator's Preface. N.

by diſtillation, I ſhall ſubjoin that of affording azotic gas by the operation of the nitric acid, of being converted into malic and oxalic acids, which are in part ſaturated with lime, and into acetous acid. I muſt even remark that it is one of the vegetable matters that have afforded me the moſt oxalic acid, and that I have conſequently propoſed to ſubſtitute it in the place of ſugar for preparing this artificial acid. I ſhall ſtill add that the cauſtic alkalis, with the aid of heat, ſoften, colour, and partly diſſolve and decompoſe it.

10. Thus there can remain no doubt reſpecting the particular nature of the ligneous matter. We ſee that it differs, by the totality of its properties, from all the other immediate materials of vegetables; that it has well-marked properties; that it ought to be conſidered as the ultimate product of vegetation, as a ſubſtance the moſt ſtrongly combined in its intimate compoſition, as the moſt inſoluble, the moſt unalterable, the moſt permanent of all that are formed in plants; and that in order to make its analyſis, or to aſcertain its nature, it is actually neceſſary that we ſhould employ more powerful means, and ſtronger agents, than for treating and decompoſing any of the other materials of vegetables. It alſo reſults from the knowledge that has been acquired reſpecting the ligneous ſubſtance, that it is the moſt highly carbonated principle of the vegetables; and that this is what renders it ſo difficult to be deſtroyed,

and the cauſe which gives to the coal that proceeds from its ſemi-combuſtion ſo much of the organization of the wood, that we can diſtinguiſh both the ſpecies of the wood, and the number of annual layers.

ARTICLE XXII.

Of the Nineteenth of the immediate Materials of Vegetables; of Tanin.

1. THE particular vegetable matter, which is now called *tanin*, was formerly confounded with what was deſignated by the name of *aſtringent ſubſtance, or aſtringent principle.* Citizen Seguin, in his reſearches upon the art of tanning ſkins, firſt diſtinguiſhed this principle from the gallic acid, which ſo frequently accompanies it in vegetable ſubſtances. He has particularly characterized it by its property of uniting with animal matters, eſpecially the albumen and gelatin, of ſeparating them from the water in which they are diſſolved, of precipitating them in inſoluble fawn-coloured flakes, and of forming with them an unalterable matter, which conſtitutes the baſis of tanned leather.

2. Tanin is procured by lixiviating tan or bark of oak, or of ſeveral other vegetables, in cold water. In this manner is obtained a liquor of a dark red colour, of an acerb and acrid taſte, which reddens the blue vegetable

colours, which is very diſtinguiſhable as a particular principle by its property of precipitating the ſolutions of glue and of albumen, and all the animal liquors that contain either of theſe matters, and of thus affording the reddiſh fawn-coloured precipitate of which I am about to ſpeak. The tanin is alſo diſtinguiſhed by the ſtrong ſmell which it diffuſes when it is diluted or diſſolved in water. By evaporating its ſolution, it furniſhes the tanin dry, and in a kind of extract which has not loſt its properties, if the liquor has not been too much heated, but is ſtill ſoluble in water, and again acquires its ſtrong ſmell when diluted, and alſo combines with the animal matters, and tans them, or renders them inſoluble and unalterable.

3. The tanin is found in a number of the barks of wood, of fruits, and of acerb vegetable excreſcences. It exiſts in ſumac, the outer ſhell of the walnut; the bark and wood of the elder, of the oak, of the aſh, of ſeveral kinds of poplars, in the nut-gall, even in the ſaps of ſome trees, and in general in all aſtringent vegetables; the Peruvian bark and the Simarouba contain a certain quantity of it. All vegetable matters that are capable of tanning ſkins ſhow by that circumſtance that they are charged with a greater or leſs proportion of this principle. It is known that in the proceſſes of tanning, the peculiar matter of the tan, or tanin, diſſolved in water, and eſpecially when it forms a ſaturated and concentrated ſolution,

penetrates the ſoftened, diſtended and inflated ſkin, combines layer by layer with the gelatinous animal matter, and forms, while it quits the water, and unites with the gelatin, a ſolid matter, of a reddiſh or fawn colour, which contracts the texture of the membranous and cellular areolæ of the cutaneous matter, ſo as to render it, if ſaturated with it, hard and brittle; that the operation is ſtopped at different periods, in order that the leather may preſerve the degree of flexibility and elaſticity which it ought to have, from the ſofteſt and moſt ductile calf-ſkins, to the ſtrong leather of which ſoles are made; and that this combination exhales for a long time the ſmell of the tanin which it contains. I ſhall treat again of this ſubject in a more detailed and explanatory manner in the hiſtory of animal matters.

4. All vegetable matters which contain tanin, more particularly the barks and the ligneous texture in which nature forms and depoſits it the moſt abundantly, contain at the ſame time ſeveral matters that are foreign to it, and from which it is neceſſary to ſeparate it, in order to have it pure, and the better to aſcertain its true properties. Mr. Prouſt, in a Memoir ſent to the Inſtitute, has given an ingenious method for obtaining this principle pure, and intereſting experiments upon its chemical characters. He has more eſpecially taken the nut-gall for the object of his reſearches. Beſides ſome portions of extractive and mucous matter, the

nut-gall contains in its ligneous texture gallic acid and tanin. The gallic acid not precipitating the ſuper-oxigenated muriate of tin, whilſt the tanin eminently enjoys this property. Mr. Prouſt has uſefully availed himſelf of it for ſeparating theſe two bodies, and obtaining them diſtinct.

5. By pouring decoction of nut-galls into a ſolution of ſuper-oxigenated muriate of tin, an abundant yellow precipitate was formed. The liquor being filtrated and ſet to evaporate, a new portion of this precipitate was ſeparated from it, which the author has called *tannate* of tin, and it afterwards retained only gallic acid, muriatic acid, and a ſmall quantity of oxide of tin. This liquor being put into a bottle half full, and ſulphurated hidrogen gas made to paſs into it, gave a brown ſulphurated oxide of tin. Expoſed afterwards to the ſun and the air for ſome days, it loſt the portion of ſulphurated hidrogen gas which it had retained, and by evaporating it, Mr. Prouſt obtained pure gallic acid.

6. The precipitate formed by the ſuper-oxigenated muriate of tin in the decoction of nut-galls, or the tanned oxide of tin or tannate of tin, diluted with a large quantity of water immediately after it had been obtained, was decompoſed by ſulphurated hidrogen gas which Mr. Prouſt cauſed to paſs into it: ſulphurated oxide of tin was precipitated, and the pure tannin remained in ſolution. The liquor

left in the air, in order that it might loſe the portion of ſulphurated hidrogen gas which it contained, was evaporated; its colour became deeper; it diffuſed to a conſiderable diſtance the characteriſtic ſmell of the tanin. Its taſte was very acerb, a little bitter without being diſagreeable: it became turbid during its cooling, and depoſited a brown powder which was diſſolved again by heat; it neither putrefied nor became mouldy; it appears eminently to reſiſt putrefaction, and it is on this account that, according to the remark of the author, the decoction of nut-galls, after having been ſtrongly mouldy, contains only tanin in an almoſt pure ſtate; evaporated to dryneſs, it afforded a brown, dry, friable matter, vitreous and brilliant in its fracture, reſembling aloes, not deliqueſcent, of a very acerb taſte, ſoluble in water, and much more ſo in alcohol. This is pure tanin in the dry extractive form.

7. Mr. Prouſt has found, ſince the proceſs by the muriate of tin, another method of obtaining the pure tannin from the decoction of nut-galls. This method, which is better than the preceding, conſiſts in precipitating this decoction by pulverized carbonate of pot-aſh, in waſhing the greeniſh-grey flakes that are obtained well with cold water, and afterwards drying them in a ſtove. The precipitate grows brown in the air, becomes brittle and brilliant like a reſin, and neverthleſs remains ſoluble in hot water: this is very pure tanin.

8. The ſolution of purified tanin, when poured into a ſolution of glue, forms in it a magma, which may be preſſed out between the fingers, which is ſoft, ductile, and appears to ſhrink together. It may be elongated, and drawn out more than the gluten of the flour of wheat, and forms in its extenſion a fine gold-coloured membrane, which contracts as it dries, and then becomes brown and brittle, vitreous, indeſtructible, inſoluble in water and in alcohol; it reſumes its properties and characters by ſoftening in hot water: the animal albumen is precipitated by this principle like the gelatin, but it does not form an elaſtic magma. The tanned gluten may be obtained with the ſimple decoction of nut-galls poured into a ſolution of glue; but as the tanin can no more be ſeparated from it without decompoſing both of theſe matters when once united, this proceſs cannot be employed for obtaining the tanin pure and ſeparate from the gallic acid, &c.

9. The ſolutions of lead being precipitated at the ſame time by the tanin and the gallic acid, can not ſerve for ſeparating theſe two materials. The red ſulphate of iron forms with tanin, according to the chemiſt of Segovia, an abundant precipitate, which at firſt is of a dirty blue colour, and becomes black by drying. This precipitate differs much, according to him, from the gallate of iron, which is very light, remains for a long time ſuſpended, and has a black colour reſembling that of Indian ink.

Pure green ſulphate of iron is as little precipitated by tanin as by the gallic acid. The gallate of iron is eaſily and entirely ſoluble in the acids; the tanate of iron, on the contrary, is decompoſed, abandons the iron to them, and depoſits the tanin pure: all the acids alſo ſeparate the tanin from water.

10. When the red ſulphate of iron is precipitated by tanin, a portion of the latter diſoxides the iron, and cauſes it to paſs again into the ſtate of green ſulphate of iron; the oxigenated tanin remains in ſolution in the liquor: it is equally obtained by the oxigenated muriatic acid, which deepens the colour of the ſolution of tanin, and cauſes it to loſe its tanning property. Mr. Prouſt, who ſays that he does not yet know the new ſtate of this oxigenated tanin, compares this principle to the gallic acid, and finds great analogies between them. According to his experiments, the gallic acid loſes, its properties, like the firſt, more eſpecially that of precipitating the ſulphate of iron in a black ſtate. This is what he believes to take place in old inks and writings; where the gallic acid becomes oxigenated by the contact of the air. Perhaps indeed theſe two materials may differ only by a ſlight proportion of their principles, as they conſtantly accompany each other in vegetables, where they appear to be formed together, and perhaps at the expenſe of each other.

11. However it may be with their analogy and their approximation, it is neverthelefs certain, in the prefent ftate of our knowledge, that the tanin is a vegetable matter much diffufed, efpecially in all the ligneous vegetables, almoft always attached to or combined with wood, well characterized by its fmell, its acerb tafte, its property of precipitating and hardening animal matters, of preferving them, and rendering them unalterable, its eminently antifeptic quality, its property of becoming coloured in the air, and of giving a brown and black dye. There is reafon to believe that this very remarkable vegetable principle is the common and general fource of the aftringent property; that it is the principal feat of the virtue which the phyficians call *antifeptic;* that it is perhaps the matter which cures fevers, and the periodical returns of difeafes, and that laftly all the beautiful and ftriking properties which it prefents, not only required that I fhould treat of them at length, but alfo deferve the attention of philofophers, of chemifts and of phyficians. It cannot be doubted but that this ftudy will lead to great and ufeful difcoveries.

ARTICLE XXIII.

Of the Twentieth of the immediate Materials of Vegetables; of Suber.

1. I PROPOSE to give the name of *ſuber* to a vegetable matter analogous to cork, and which perſents chemical characters ſimilar to thoſe of that body. This matter covers all the vegetables, and forms their epidermis; it is a dry membrane, brittle, thin, ſemi-tranſparent, eaſily rolling together by the contact of the dry air, inſipid, inſoluble in water, and yet ſeparable from the bark by the abſorption of this liquid, and the inflation which it receives from it. Cork, properly ſo called, ſeems to be only this matter more indurated, condenſed, and accumulated, ſo that the epidermis of every tree, conſidered under this relation, is only a layer of cork.

2. Though it was very probable, from the mere aſpect and external properties of cork, which diſtinguiſh it ſufficiently from all other vegetable matters, that it was really a ſubſtance different from all others, it was not till 1787 that Mr. Brugnatelli firſt publiſhed an obſervation that ſerved to characterize cork as a particular matter. By diſtilling nitric acid upon this ſubſtance, beſides the corroſion and the yellow colour that were already known to be produced

upon

upon it by the contact of the acid, this philoſopher diſcovered that there was formed a particular acid different from all others before known. Citizen Bouillon La Grange has ſince examined this acid, which had only been announced by Brugnatelli, and has given an account of ſeveral of its properties, as well as of thoſe of the cork itſelf. It was already known that cork is very light, very combuſtible, that it gives a white and brilliant flame; that it leaves a very light, very black, ſwelled coal, that it affords a little ammonia by diſtillation.

3. When we wiſh to treat this body by the nitric acid, the acid muſt not be taken too much concentrated nor containing too much nitrous gas, for it is ſuſceptible of inflaming it. Carbonic acid gas and nitrous gas are diſengaged during the reciprocal action of the cork and the acid. In proportion as the cork is converted into ſuberic acid, there is ſeparated a yellow ſoft matter, which ſwims at the ſurface of this liquor, and is a particular fat matter, much reſembling reſin or fat: theſe are the yellow fragments which are ſeen ſwimming upon the nitric acid into which cork-ſtopper have fallen.

4. By the evaporation of the nitric acid that has acted upon cork, ſmall needles of ſuberic acid of a fawn-yellow colour are ſeparated. Citizen La Grange has employed two means for purifying it: the one conſiſts in combining it with an alkali, evaporating the well-filtrated ſolution to the conſiſtence of a ſyrup, afterwards

precipitating it by a ſtronger acid, ſuch as the muriatic, and waſhing it well with cold diſtilled water. The ſecond means is to boil the yellow ſuberic acid with a little water and pulverized charcoal, and to filtrate the hot liquor; the acid is depoſited by cooling, in the ſolid and cryſtalline form; it is much leſs coloured than it was at firſt: the remainder is obtained by evaporating the ſupernatant liquor. It has a harſh and acerb taſte; it reddens the blue vegetable colours; it becomes black by the contact of light; by a mild heat it is volatilized without being decompoſed; it is liquefied by the contact of oxigen gas; it diſſolves in water of which it requires at leaſt fifty parts when it is cold; hot water diſſolves much more, and it is ſeparated from it in part by cooling, in the cryſtalline form.

5. The acids with ſimple radicals do not act upon the ſuberic acid unleſs when they are concentrated, and then they burn it. Alcohol diſſolves it better than water, and aſſumes with it a ſmell of Eau de Noyau or almonds. The combinations of the ſuberic acid with the earths and the alkalis are more or leſs ſoluble: ſome of theſe ſuberates cryſtallize well, others with difficulty; there are ſome which remain in the pulverulent and inſoluble form, whilſt others are deliqueſcent. The ſtrong acids decompoſe them and precipitate from their ſolutions the ſuberic acid which ſeparates in the cryſtallized form.

6. The ſuberic acid attacks few of the metals, if we except iron and zinc; it unites with almoſt all the oxides and forms with moſt of them inſoluble ſalts; it changes the colour of the ſalts of zinc, of iron, and of copper; it precipitates the nitric ſolutions of lead, of mercury and of ſilver in a white powder. Citizen La Grange has began to determine the elective attractions of this acid, and he has found them to be, with reſpect to the alkaline and earthy baſes, in the ſame order as thoſe of the ſulphuric, nitric and muriatic acids for theſe baſes. He has not yet been able to appreciate thoſe which it exerts upon the metallic oxides.

7. The bark of the variety of the knotty kind of elm which is called the *twiſted elm*, and which has the thickneſs, the ſoftneſs, the elaſticity and the poroſity of texture of cork, preſented to Citizen Vauquelin properties very much analogous to thoſe of cork properly ſo called, and ſome experiments made upon the epidermis of ſeveral trees have preſented to me ſufficiently marked analogies with this epidermoid ſubſtance of the oak which affords the real cork, to lead me to think that I ought to approximate all theſe matters under the generic name of *ſuber*, as forming really one of the diſtinct and conſtant materials of vegetables. It will require future labours and new reſearches to aſcertain more accurately the nature of this body, which merits all the attention of chemiſts.

8. Neither do I doubt but that this body, which ſo much reſembles the ligneous texture and the vegetable colouring matter, contains a certain proportion of azote amongſt its principles; and though I have yet little poſitive knowledge reſpecting its nature, at leaſt beyond what is ſufficient for diſtinguiſhing it from the other immediate materials of plants, it is however ſufficient to point out an analogy which exiſts, found between vegetables and animals, in the circumſtance that their body is ſurrounded and covered with an inſoluble texture, impervious to water, different from all the other textures of which they are formed, and really deſtined to perform a particular function in their organization.

Article XXIV.

Of the different Matters more or leſs analogous to Foſſil or Mineral Subſtances which are found mixed or combined with the immediate Materials of Vegetables.

1. IT has been ſeen by the numerous facts collected in a great number of articles of this ſeventh ſection, that all the immediate materials of vegetables are formed, in their firſt principles, of carbon, of hidrogen and of oxigen; that azote alſo enters amongſt them in ſome, which then

approach to the animal matters; that the ſingular variety of form, of conſiſtence, of taſte, of ſmell, of colour, and of all their chemical properties, depends almoſt ſolely upon the different proportion of theſe primitive principles, and that it requires only a very ſlight variation in this proportion to give riſe to a very great one in their varieties. But beſides this general uniformity of compoſition, which admits in the diverſity of their reſpective quantities of principles the cauſe of their diverſity of nature, there is another ſource of ſome differences between theſe materials, the influence of which muſt here be explained, and its relations with the properties of theſe materials themſelves determined.

2. This cauſe exiſts in bodies foreign in ſome meaſure to their intimate nature, which ſometimes form part of their compoſition, or which vary ſome of their properties, though they are only diſſeminated, temporary or acceſſary to them. Theſe bodies, foreign to the vegetable compoſition, are foſſil matters, moſt frequently drawn up from the earth by the capillary tubes of the roots, and carried into the veſſels of the plants with the juices or the water which theſe organs inceſſantly abſorb from it. They are in general of two claſſes, either ſimple or compound matters. I refer them; *a.* to the undecompoſed combuſtible bodies; *b.* to the metals; *c.* to the acids; *d.* to the earthy and alkaline baſes; *e.* to the ſaline ſubſtances; and I ſhall conſider them in this order.

3. Amongſt the ſimple combuſtible bodies, ſulphur and phoſphorus are frequently met with in plants. Sulphur has been found in many of the cruciferous plants; their diſtilled waters, alcohol diſtilled upon theſe plants in the pharmaceutical preparations, depoſit ſulphur, even in the cryſtallized ſtate by long ſtanding. In putrefying, theſe vegetables exhale the fetid ſmell of ſulphurated hidrogen gas; the water, charged by diſtillation with what was called their *ſpiritus rector* or *aroma*, comports itſelf like a real ſolution of this gas in ſmall quantity, and depoſits ſulphur whenever this gas is decompoſed by the contact of the air and the abſorption of the oxigen. According to the experiments of Citizen Deyeux, ſulphur is extracted in powder from the fecula of the root of patience, or from this root raſped and waſhed in water, or from the ſcum which it forms when it is boiled in that liquid. Margraff has extracted phoſphorus from muſtard-ſeed heated by a ſtrong fire in diſtillation, and the phoſphoric acid of the bog-ores, and alluvial-ores, particularly of thoſe of iron is attributed to the aquatic plants under which theſe ores are formed.

4. Iron is frequently found in the ſtate of oxide in plants; it is even ſaid to have been found in metallic grains in ſtrawberries. The oxide of this metal frequently exiſts in the aſhes of vegetables. It is ſaid that thoſe of the hard woods, eſpecially of the oak, contain one twelfth of their weight of it. The colours of plants

and that of their flowers was formerly attributed falſely to this metal. It cannot be doubted that it paſſes from the interior of the earth through the roots. Scheele has found the oxide of manganeſe as frequently as that of iron in vegetable aſhes, and it is probable that what has frequently been taken for iron was only the oxide of this metal. Some chemiſts, with Becher and Kunckel at their head, admit the preſence of gold in plants; but the very ſmall quantity of this metal that can be extracted from their aſhes, and which is ſeparated from them only by means of fuſion with lead, appears to proceed rather from the latter than from the aſhes themſelves, as has been proved by perſons of greater accuracy than thoſe who have renewed in our days this antiquated pretenſion of chemiſtry.

5. Amongſt the ſimple burned bodies (after water which, without being a real vegetable matter appears to be eſſential to the nature of plants, and neceſſarily to form a conſtituent part of their materials, which it dilutes and tranſports), there are only a few acids which are met with in the products of vegetables; only the carbonic acid is found pure in them; but it appears to be ſo frequent and ſo abundant, eſpecially in the ſaps, that it ſeems to form one of the principal nutriments of plants, as I ſhall ſhow elſewhere. None of the other acids that are extracted from them exiſts in them in a pure ſtate, but always combined with earthy and al-

kaline baſes: ſuch is the ſtate of the ſulphuric, nitric, muriatic, and phoſphoric acids, which are united in them with pot-aſh, with lime, and ſometimes, though much more rarely, with ſoda, in ſaline combinations.

6. Several of the earthy and alkaline matters, of which I have given an account in the fourth ſection of this work, exiſt alſo very frequently amongſt the materials of vegetables. Silex is found in almoſt all their aſhes; it is ſometimes in concretions, as in the *tebaſheer.* Alumine exiſts in them, but much leſs than has been ſaid. Magneſia is in the ſame predicament. Lime is much more abundant in them, and is found eſpecially combined with the ſulphuric, phoſphoric, or carbonic acids. Pot-aſh is found ſo frequently in them, and forms ſo large and conſtant a part of their burned reſidues, that it was formerly conſidered as belonging excluſively to plants, and on that account called *vegetable alkali.* It was even believed that it was found only in vegetables, that it was peculiar to them, and that it was formed by the very act of vegetation. Though it is well aſcertained that this alkali is found amongſt foſſils, and that it even forms one of their principles, eſpecially in the volcanic products, as I have elſewhere indicated, it is moſt frequently from vegetable matters that it is extracted. After having burned herbs, and eſpecially woods, their aſhes are lixiviated, this lixivium is evaporated to dryneſs, and in this manner the crude pot-aſh or *ſalin* is obtained; this

ſalt is calcined in ovens, where it is kept red-hot for ſeveral hours: it is in this manner that the pot-aſh of commerce is prepared. It contains, beſides the portion of cauſtic pot-aſh, which is expected, carbonate of pot-aſh, ſulphate of pot-aſh, muriate of pot-aſh, ſulphate of lime, phoſphate of lime, frequently oxide of iron, oxide of manganeſe, ſilex: all theſe foreign matters are ſeparated by lixiviating them in very little water, by keeping this lixivium for a long time in the air, in order that the ſilex may be precipitated from it in proportion as the alkali abſorbs the atmoſpheric carbonic acid; or elſe, if it is wiſhed to obtain the pot-aſh pure, by treating it with alcohol, either immediately, or after having mixed it with quick lime, in order to decompoſe the carbonate of pot-aſh which it contains: in this manner much more of cauſtic pot-aſh is obtained than when the alcohol, which does not touch the ſalts, is employed alone and immediately in order to diſſolve it.

7. Soda is much more rarely contained in vegetables than pot-aſh; thoſe only which grow in the water of the ſea furniſh it by combuſtion; and it has elſewhere been ſeen that it is only by the incineration of the kalis, the vareks, and the fucus, that ſoda is obtained upon the ſea-coaſts. It is moſt frequently combined in plants with the muriatic acid, ſometimes, though much more rarely, with the ſulphuric acid. It appears, according to the analyſis of the ſalſola ſoda, made by Citizen

Vauquelin, that ſoda exiſts alſo in the pure and cauſtic ſtate in marine plants.

8. The ſalts, properly ſo called, or the ſaline combinations of ſeveral of the acids with ſimple radicals, with earthy and alkaline baſes, are alſo met with in plants; they are even the foſſil matters that are found in them the moſt frequently, and that are extracted from them the moſt eaſily. They are extracted from their evaporated juices; they effloreſece upon their extracts; they are ſeparated from their aſhes. Such are particularly the ſulphate of pot-aſh, that of ſoda and of lime, the nitrate of pot-aſh, the muriate of pot-aſh, the muriate of ſoda, and the phoſphate of lime.

9. There is reaſon to think that all theſe foſſil matters, the quality of which varies inceſſantly amongſt the vegetable products which are not neceſſary to their conſtitution, which are only acceſſary, and as it were accidental amongſt their immediate materials, which in a word may vary greatly in their proportion and their diverſity, without changing the nature itſelf of theſe materials do proceed immediately from the earth in which the roots of the plants are plunged, and that they have been abſorbed by the roots of theſe beings with the water, which eſpecially ſerves for their nouriſhment; accordingly they depend upon the nature of the ſoils in which theſe roots are placed.

10. Some natural philoſophers have, however, thought that vegetation gave riſe to them, that

they were formed in a direct manner in the organs of the plants themſelves: this opinion has eſpecially been adopted as to pot-aſh and nitre. There are ſome chemiſts who even carry this notion ſo far as to believe that iron is alſo formed by the powers of vegetable life; but far from acquiring or diſcovering proofs of this opinion in the facts, it appears that it becomes leſs and leſs probable in proportion to the progreſs which analyſis makes; whilſt the opinion which admits the paſſage of theſe matters from the ſoil itſelf into plants, receives every day additional confirmation.

Fifth Order of Facts, reſpecting the Vegetable Compounds.

Of the ſpontaneous Alterations of which theſe Compounds are ſuſceptible.

Article I.

Of the Nature and general Cauſes of theſe Alterations.

1. ALL the phenomena, all the facts hitherto collected reſpecting vegetable compounds, proves, as has been ſhown in the preceding articles, that theſe compounds, being more complicated in their compoſition than thoſe which belong

to the foſſils, are alſo for the ſame reaſon much leſs permanent than the latter. The attractions which exiſt between their primitive principles, at leaſt to the number of three, permit them but rarely to remain permanent in their firſt ſtate; unleſs when their molecules being very cloſe together, and very much condenſed, do not admit between them any foreign ſubſtance, which may ſeparate them, and ſolicit thoſe of their component parts to re-act upon one another.

2. As ſoon as the circumſtance of the ſeparation of their integrant molecules takes place by the intromiſſion, either of thoſe of caloric, or of thoſe of water, which is always accompanied with the former of theſe bodies, the equilibrium of their compoſition is then ſpeedily broken, the attraction between the primitive bodies which compoſe them is changed, and aſſumes another mode; and by uniting in another manner, by tending to combine two and two, or each ſeparately, with thoſe that are moſt accommodated to them, they induce the more or leſs entire diſſolution of the firſt compound, its more or leſs profound alteration, its more or leſs complete decompoſition.

3. Such is in general the two-fold firſt cauſe of all the ſpontaneous alterations of which vegetable matters are ſuſceptible: the one reſides in the nature of their compoſition itſelf, in the weakneſs of the equilibrium which holds their principles united, in the diſpoſition which

they have to ſeparate in order to combine in another order. Nature, having intended only a tranſient and temporary adheſion in theſe vegetable compounds, has imprinted upon them the character of variability and inconſtancy: the other cauſe conſiſts in the intromiſſion of the molecules of any bodies between their own; an intromiſſion which, by weakening the connection which keeps them united, by diminiſhing their peculiar attraction, diſpoſes them to ſeparate, cauſes them to unite in another order, to form new compounds, and to appear under new forms and with new properties.

4. It is conſtantly obſerved that the effect of the inteſtine movements, which occaſion thoſe ſponaneous changes of nature and compoſition, that the particular conſequence or the regular and determined ſeries of theſe movements, produce in general compounds leſs complicated than thoſe which have been thus ſubjected to them. Thus the hidrogen tends to unite with the oxigen and to form water; the hidrogen tends to combine with the azote, and to conſtitute ammonia; the carbon to ſeize ſeparately upon the oxigen, and to compoſe the carbonic acid. Such is alſo the conſtant termination of theſe alterations which, when conſidered under this point of view, reſemble the effect produced by the action of fire, or by that of the powerful acids, the moſt energetic oxigenated bodies.

5. But before the laſt terms of the ſpontaneous, of which theſe vegetable compounds are

ſuſceptible, is attained by the decompoſition which they undergo, they ſtop at different periods, they remain in different intermediate ſtates, they paſs through ſeveral ſucceſſive terms in which they have acquired particular characters, diſtinctive properties which may be eaſily diſcerned, and in which, by attentively watching the periods when they arrive, it is poſſible to interrupt their continuation, and to fix them in ſuch a manner as to prevent the alteration from advancing farther, or being longer continued.

6. Since obſervation has aſcertained this natural attraction of the vegetable compounds, as well as the cauſes or general circumſtances which favour it, it muſt not only throw a light upon a multitude of effects and productions which are its natural conſequences amongſt the numerous phenomena of nature, but it has has alſo led me to inveſtigate the means either of producing theſe alterations at pleaſure, or of carrying them to the point which we wiſh them to attain, or of fixing them at the period which we may find uſeful for our wants, or finally of entirely ſtopping them, and preventing them from taking place; and all the means which are at the diſpoſition of the arts are employed by man with more or leſs ſucceſs, and varied, according to the products which he may wiſh to procure.

7. The ſcience, after a long courſe of obſervations upon the ſpontaneous alterations to which the vegetables are ſubject, and which

they experience in a manner, varied according to circumſtances, and the different agents to which they are ſubjected, has been under the neceſſity of diſtinguiſhing the nature itſelf of theſe alterations into ſeveral ſpecies. It conſiders in ſucceſſion, and in this order the fermentations, the gradual decompoſitions in the air, the ſlow and ſubterraneous action of waters, the influence of the ſoil, and the different kinds of earth upon the vegetables that are buried in it, and conſequently paſſes in review, in the courſe of theſe important conſiderations, the varied products of theſe alterations; thoſe of the fermentations, the putrefied woods, the moulds, the bitumens, the foſſil vegetables, the petrifactions, &c.

8. This manner of deſcribing and conſidering the ſpontaneous alterations of vegetable matters, which is infinitely more methodical than any that has hitherto been attempted in Elementary Treatiſes of Chemiſtry, has the advantage of preſenting, in a well-arranged ſyſtem, the totality and the ſeries of ſeveral bodies which has formerly been erroneouſly referred to the mineral kingdom. I need not remark that all theſe alterations take place only upon vegetables deprived of life, that vegetation repels them, that their effects may be conſidered as the means of natural analyſis, and that by obſerving them with much attention, the ſcience may derive great light with reſpect to the nature and compoſition of vegetable ſubſtances. This laſt point, as well as

that of the utility of the products formed in conſequence of theſe alterations, ſhall particularly occupy the ſubſequent articles.

ARTICLE II.

Of the Fermentations in general, and of their Diſtinction into ſeveral Species.

1. AS the changes which take place in vegetables by their ſpontaneous alterations are almoſt always accompanied with an inteſtine movement which agitates them, raiſes them, and ſeems to torment their maſs, the phenomenon itſelf by which the vegetable matters thus ſubjected to the eye of the obſerver in the air, or in open or tranſparent veſſels undergo theſe changes, has been called fermentation; ſo that no modification dependant upon their intimate nature, and ſuſceptible of changing this nature itſelf, is ſaid to take place without fermentation.

2. It was ſoon perceived in the ſcience that this ſpontaneous alteration varies ſingularly in vegetable matters, according to the difference of their nature; and as every internal variation or change dependant upon the nature of theſe matters itſelf, and taking place without the neceſſary intervention of a foreign agent, has, from that circumſtance alone, the character of a fermentation, it was natural for che-

miſts to diſtinguiſh the different ſpecies of fermentation.

3. Boerhaave firſt diſtinguiſhed three fermentations, the firſt of which he called the *ſpirituous fermentation;* the ſecond, the *acid* or the *acetous fermentation;* the third, the *putrid fermentation.* He conſidered them as eſtabliſhed by nature in a conſtant order, and following each other regularly in that which I have juſt enunciated. Thus the ſecond, according to him, could take place only after the firſt, and the third only after the ſecond; whence it is eaſy to ſee that he conceived them as a ſeries of inteſtine movements linked together by an equal and intimate cauſe, ſucceeding each other by an indiſpenſable neceſſity, and mutually exciting each other.

4. Though ſeveral chemiſts have propoſed ſome modifications of this ingenious ſyſtem of Boerhaave, moſt natural philoſophers have adopted all his notions, and this courſe has long been followed in the ſchools. That of Rouelle eſpecially has greatly contributed to propagate, and even to extend it. Each of theſe fermentations was diſtinguiſhed by its product. That which was called *ſpirituous* had for its product *ſpirit of wine,* or *ardent ſpirit,* which is now called *alcohol*; that of the ſecond, or of the acid fermentation, was vinegar; and on this account it was called acetous, after Boerhaave; laſtly, the putrid fermentation bore the name of alkaline, becauſe the volatile alkali, or ammonia,

monia was conſidered as its eſſential or conſtant product.

5. Some chemiſts, and eſpecially Bucquet, in the laſt years of his life, and in his laſt lectures, from 1776 to 1779, believed that this diſtinction into three ſpecies was not ſufficient to comprehend all the alterations or fermentations of which the vegetables are ſuſceptible. They adduced, as proofs of their opinion, the riſing of dough, or the panary fermentation; but this manifeſtly tends to form an acid, and enters into the ſecond ſpecies of Boerhaave: and the fermentation which develops itſelf in the colouring parts, ſuch as thoſe of the indigo-plant and paſtel.

6. By conſidering this ſubject in all its extent, and under all its aſpects, I have found that there are actually ſeveral kinds of fermentative movements, which are different from the three fermentations diſtinguiſhed by Boerhaave, either by their phenomena or by their product; that it was neceſſary to add at leaſt two very diſtinct ſpecies to the three admitted after the celebrated profeſſor of Leyden; and that in proportion as more attentive and accurate inveſtigation ſhall be made into the circumſtances, the conditions, and the effects of thoſe ſpontaneous movements which the different vegetable matters undergo, we ſhall naturally be led hereafter to multiply their ſpecies ſtill more, and to determine their real differences.

7. I therefore admit five ſpecies of vegetable fermentations; the firſt is the *ſaccharine* fermentation; the ſecond, the *vinous* fermentation; the third, the *acid* fermentation; the fourth, the *colouring* fermentation; and the fifth, the *putrid* fermentation. Their diſpoſition announces that they follow each other in the order in which they have been enunciated; that there is one which precedes that which Boerhaave conſidered as the firſt, and another placed between the acid and the putrid fermentation. I ſhall here treat of them ſucceſſively in ſeparate articles; but I muſt firſt preſent a few general truths.

8. The firſt of theſe general truths is the neceſſity of well diſtinguiſhing the fermentative alteration from the other ſpontaneous changes of which the vegetables are ſuſceptible: for example from thoſe which they undergo, when, otherwiſe deprived of the conditions neceſſary to the effect of fermentation, they are immerſed in water, or buried in dry earth. Here not only the circumſtances which I may call fermentiferous are wanting, but the vegetables are themſelves ſubjected to the action of other agents capable of retarding or ſtopping their fermentation, or of acting in ſome other manner upon their compoſition. Accordingly, in the order of facts with which I am here occupied, I diſtinguiſh the formation of the ſoil, that of the bitumens and foſſilization, properly

ſo called, from the fermentations. Though the very nature of the vegetable matters, which undergo the one or the other of theſe alterations, conſiderably oppoſes any real fermentation, I ſhall ſhow, in treating of theſe phenomena, and of their products, that the extraneous circumſtances, that the inſtruments or the agents in which the vegetables are immerſed when they experience the effects very different from fermentations, modify the kind of alteration which they undergo in a very different manner.

9. A ſecond truth ſtill more nearly relating to the hiſtory of fermentation in general is, that no vegetable matter can undergo it, unleſs it be penetrated with a certain quantity of water, which, as I have already announced in the preceding article, ſeparates its particles, diminiſhes their own attraction, and diſpoſes them to act reciprocally upon one another. This neceſſity of water is ſo indiſpenſable, that the ſureſt means of preventing all fermentation conſiſts in depriving the vegetable matters completely of this liquid, by totally drying them. In the dry ſtate, theſe bodies preſerve the integrity of their compoſition; they undergo no kind of alteration or change. It is ſufficiently known, from the hiſtory of grains and ſeeds of every kind, that they are only to be preſerved ſound by keeping them in dry places, defended againſt all kind of moiſture;

from that of plants of all kinds, of roots, ſtalks, flowers, and fruits, which are only preſerved during ſeveral ſeaſons, and even whole years, after they have been dried in the ſun or in ſtoves; and laſtly from that of the pulps, the powders, the farinæ, the extracts of all the pharmaceutical vegetable preparations, the purity and the properties of which cannot be preſerved, unleſs by reducing them to a ſtate of perfect dryneſs, and incloſing them in veſſels well defended againſt humid vapours.

10. The third truth which I muſt place here, in order to elucidate the general conditions of fermentation, and render their particular theory better underſtood, is, that a certain elevation of temperature is neceſſary to the production of this movement: no fermentation is known below the freezing point, and even moſt of thoſe movements do not begin to be excited, except at temperatures elevated above fifteen degrees of Reaumur's thermometer. Thus all fermentation is ſtopped, or rather it cannot take place under the poles, in the frozen countries and ſeaſons: and thus, on the contrary, the hotter climates preſent the fermentations in all their power, in all their activity. However, in the torrid zones, ſituated under the equator, theſe movements take place only in the more fluid vegetable matters, or in thoſe which contain much water; for thoſe which are provided only with a ſmall quantity loſe it quickly, and dry with ſuch celerity in the

torrid regions, that this firſt effect in general oppoſes the proceſs of fermentation.

11. Though theſe two circumſtances, water and heat, are the two moſt eſſential conditions of fermentation in general, their neceſſity or the proportion of their influence in ſome reſpect varies for each ſpecies of fermentation. There are ſome which require only a ſmall proportion of water and a temperature little elevated; others, on the contrary, require much liquid and a pretty ſtrong heat. But theſe details belong to each fermentation in particular.

12. It has long been remarked that by mixing with a vegetable ſubſtance ſuſceptible of fermentation, a portion, frequently even a very ſmall one, of the ſame matter which has already fermented, the firſt paſſes into the fermentative motion with much greater celerity than if it had been alone, and paſſes through it in a much more rapid manner. Every one knows that it is in this manner that the dough of wheat is made to riſe more conſiderably, and to ferment more quickly, by adding a ſmall quantity of yeaſt or of dough that has already riſen, known by the name of *leaven.* The chemiſts, ſince Stahl who wrote a particular work upon this ſubject, have eſtabliſhed a theory of what were called *ferments,* which has been much abuſed in medicine, into which it has been transferred. They have believed that no fermentation could be produced without the addition of an already fermented matter or a

ferment. The phyſicians, on their part, have thought that a ſimilar effect took place in a multitude of diſeaſes, and that particularly all thoſe which proceeded from a virus, eſpecially the affections communicated by inoculation, by the introduction of any matter, owed their origin only to an inteſtine movement occaſioned by a ferment. It is at preſent well underſtood, that though foreign bodies introduced between the particles of different vegetable ſubſtances, favour the movement of fermentation to which they are naturally diſpoſed, it is not neceſſary that theſe bodies ſhould themſelves have fermented; and that, though in the latter caſe the fermentation is generally eſtabliſhed in a more rapid and more evident manner, yet every extraneous ſubſtance capable of removing the particles aſunder, and diminiſhing their reciprocal adheſion, enjoys the ſame property; thus the carbonic acid, by its character of eaſily aſſuming the gaſeous form, of occupying a large ſpace, conſequently of removing the particles of the bodies between which it is lodged, has more eſpecially the property of giving riſe to fermentation in them, and of developing more quickly that inteſtine motion which tends to effect a change of their nature, as appears from the reſearches of Mr. Henry, an Engliſh chemiſt.

ARTICLE III.

Of the Saccharine Fermentation.

1. I TERM the ſaccharine fermentation an an inteſtine and ſpontaneous motion, which is frequently excited in ſeveral vegetable ſubſtances, and by which a ſaccharine matter is formed in them, which did not previouſly exiſt there. Since this phenomenon really exiſts, and ſince, without the action of any external agent or inſtrument foreign to the neceſſary conditions of fermentation, an inſipid vegetable ſubſtance becomes truly ſaccharine, it is impoſſible not to admit in this ſpontaneous production an actual fermentation. The facts which I am about to collect will place this truth out of all doubt.

2. I place this fermentation in the firſt rank, becauſe it really precedes the vinous fermentation which Boerhaave had conſidered as the firſt. In fact, we ſhall ſoon ſee that the preſence of a ſaccharine matter is indiſpenſably neceſſary to give riſe to the formation of a vinous liquor; that all the mucous, inſipid ſubſtances are abſolutely incapable of experiencing this vinous fermentation; that all thoſe, on the contrary, which have a more or leſs ſaccharine taſte, are evidently ſuſceptible of it; and that the not ſaccharine or inſipid ſubſtances, which ſometimes

times paſs into the vinous ſtate, cannot arrive at this ſtate without previouſly contracting the taſte and all the properties of the ſaccharine matters.

3. This tranſition of the inſipid matters into the ſtate of ſaccharine ſubſtances belongs to a fermentation, and it is this which I term *ſaccharine*, becauſe its product is ſugar. I do not mean to imply that the formation of the ſaccharine matter depends always and neceſſarily upon this ſpecies of fermentation; or that becauſe a vegetable matter is ſaccharine, it has undergone this particular movement: it would be equally neceſſary to ſuppoſe that there could be no vinegar or acetous acid without the acid fermentation and the inteſtine change of a wine; whereas a multitude of chemical facts, ſeveral of which I have already preſented upon former occaſions, and to which I ſhall hereafter add ſome others, prove that acetous acid is formed by other circumſtances beſides fermentation; and we have ſeen it particularly in the action of the ſulphuric and nitric acids upon the inſipid, viſcous and dry vegetable matters. The ſame is the caſe with ſugar: ſome ſugars are formed in vegetable matters by the progreſs of vegetation itſelf; but there are ſome alſo which are produced by a kind of fermentation; and it is of this that we have to treat in the preſent article.

4. One of the firſt proceſſes in the art of brewing will be ſufficient to prove the exiſtence of the ſaccharine fermentation. It is known that

barley, wheat, maize and moſt of the cereal ſeeds, penetrated firſt with a certain quantity of water, and afterwards expoſed in heaps to a temperature above 12 degrees, ſwell and announce the inteſtine movement that is excited in them by the development of the germ which ſprouts out of theſe ſeeds. At this period the brewer ſtops this motion; he heats and dries theſe germinated ſeeds by the action of the fire in the malt-kiln; and when they are well dried, he grinds them in order afterwards to prepare a decoction of them, which then is capable of fermenting and affording beer. The grain in this ſtate has acquired a ſaccharine taſte, and the water which has been boiled upon this matter has extracted from it a real ſaccharine ſubſtance which may be obtained from it by evaporation. Previous to this fermentation, it was inſipid and ſimply farinaceous, and it is a portion of this inſipid matter which has become ſaccharine by a real fermentation, and by the inteſtine motion of its own particles removed from each other by the water and the caloric; for it is impoſſible to attribute this phenomenon to any other cauſe.

5. It cannot be doubted that this ſaccharine fermentation takes place in all the cereal grains, perhaps in all the monocotyledonal ſeeds which germinate. The germination itſelf appears to be its neceſſary conſequence, or at leaſt conſtantly to accompany it. All the germinated ſeeds are in fact ſaccharine, and I have obſerved a ſufficient number of them in this ſtate, to in-

duce me to think that this phenomenon is general; it is not improbable that many of the dicotyledonal ſeeds preſent the ſame character during their germination. Thus the ſaccharine fermentation, or the converſion of the mucous, inſipid and feculent ſubſtance into ſugar, by the effect of germination, may be reckoned amongſt the number of the firſt chemical phenomena which vegetation preſents.

6. There exiſt many other circumſtances of the vegetable analyſis in which a ſaccharine matter is formed at the expenſe of another matter which was not previouſly ſuch. Such eſpecially is the maturation of fruits; it is univerſally known that fruits are gathered from a great number of trees when they are very far from being ripe and ſaccharine, that their maturation takes place only in the fruit-houſes where they are kept, and require periods of longer or ſhorter duration. This obſervation is eſpecially applicable to apples and pears, though it may be extended to a great number of other fruits. Theſe bodies, at the time when they are gathered from the trees, have frequently only a harſh, acerb, ſour and diſagreeable taſte: this taſte ſoon experiences certain modifications; they become ſweet, ſaccharine and agreeable; and it is too evident to require a more profound diſcuſſion, that in this caſe the fruits experience, in their pulp or parenchyma, an inteſtine change which may be attributed to a real fermentation.

7. The ſame modification, though not proceeding from the ſame cauſe, is remarked in ſeveral domeſtic operations. Baking in wood-aſhes or boiling in water gives many roots and fruits a ſaccharine taſte which they did not previouſly poſſeſs, and appears to develop in them this particular matter, by means of the change which the ſtrong action of the fire has produced in their principles. The caſe is the ſame with the effect produced by ſome re-agents, eſpecially by the powerful acids, in ſeveral inſipid vegetable ſubſtances, eſpecially in the germens and the amilaceous fecula. The muriatic acid gas, eſpecially the oxigenated, frequently communicates to their ſolution in water, together with a reddiſh colour and the conſiſtence of ſyrup, a ſaccharine taſte, which announces the manifeſt tranſition from the ſtate of mucous matter to that of ſaccharine ſubſtance. Laſtly, ſome modern phyſicians, Meſſrs. Rollo and Cruikſhank, think that this ſame inſipid and mucous ſubſtance is frequently converted into ſaccharine matter in the human ſtomach, when the digeſtive power or energy of its gaſtric juice are diminiſhed; they even attribute to this impaired and ſaccharine digeſtion the cauſe of a diſeaſe, which appears to be more frequent in England than in France, called the *Diabetes mellitus*, on account of the ſaccharine taſte of the urine which is diſcharged in great abundance by the patients affected with it. It is evident that in this caſe, the confirmation of which muſt be

awaited from ſubſequent obſervations, a real ſaccharine fermentation takes place in the ſtomach. Something ſimilar takes place in the ſtomach or the muſcular glands of females that ſuckle their progeny.

ARTICLE IV.

Of the Vinous Fermentation and its Products, Wine and Alcohol.

1. VINOUS fermentation is the name given to that which Boerhaave called the *ſpirituous*: the latter appellation was derived from that of ſpirit of wine, which was given to the product of the diſtillation of wine; but this laſt, being the true product of the fermentation in queſtion, it is more natural and more accurate to call this fermentation *vinous*, and particularly ſince the denomination of ſpirit of wine which was formerly given to this liquid has been rejected. The hiſtory of the vinous fermentation being one of the moſt important and moſt uſeful parts of vegetable chemiſtry, ought to be treated with the greateſt attention and in a ſufficiently detailed manner to render it perſpicuous and complete. I therefore divide this article into ſix paragraphs. The firſt ſhall treat of the definition and the literary hiſtory of the vinous fermentation, the ſecond of the conditions which it requires;

quires; the third of the phenomena which it preſents; the fourth of the immediate product which it yields, or of wine; the fifth of the remote or ultimate product which is obtained from it, namely alcohol; and the ſixth ſhall be devoted to the examinations of the cauſes of the mechaniſm of this fermentation and of the formation of alcohol.

SECTION I.

Definition and Literary Hiſtory of the Vinous Fermentation.

2. I HAVE remarked that this fermentation is called vinous, becauſe its actual product is wine; and this is ſo true that it is its conſequence and neceſſary effect. It ought not to be called ſpirituous, not only becauſe the abſurd denomination of *ſpirit of wine* has been rejected, but becauſe this is not its product or immediate production: it has not therefore been called *alcoholic* fermentation, as it ought to have been, if this firſt idea of its nature and its effect had been adopted.

3. Boerhaave was the firſt chemiſt who endeavoured to diffuſe the lights of ſound natural philoſophy over the nature of fermentation, and endeavoured to explain its cauſe and phenomena. He has had the merit of renouncing the

falſe theories which had been ſet up before him concerning the nature of this movement; he perceived that the ſtate of phyſics in his time was not ſufficiently advanced to afford a proper notion of its real cauſe. The defective natural philoſophy which prevailed for a long time in the ſchools in the explanation of chemical phenomena, attributed the vinous fermentation to the motion and reciprocal friction of the particles, and explained nothing by attempting to explain every thing. Becher had an idea much nearer to the truth, though ſtill far from preciſe and exact, though at leaſt ſufficiently ingenious, when he compared fermentation to a kind of combuſtion.

4. From Boerhaave to Rouelle and Macquer, nothing accurate was advanced reſpecting the vinous fermentation, but its phenomena were ſtudied and better deſcribed: the deficiencies of the hypotheſis, which till then had been maintained, were gradually perceived, and adopted with more or leſs ardour, or maintained with more or leſs zeal. Macquer, without diſcovering any thing new reſpecting the mechaniſm of this ſpontaneous commotion, collected in a more accurate manner than his predeceſſors the totality of its phenomena; he has given ſome exact experiments towards improving the fabrication and the nature of wines.

5. Many philoſophers and chemiſts have ſince laboured upon the proceſſes of the different kinds of vinification, upon the difference

of wines, upon the art of aſcertaining their quality, of correcting their defects, of obviating their depravations, of analyzing them, of improving their uſeful properties, and of ſeparating their alcoholic product. Amongſt theſe authors we muſt particularly diſtinguiſh Rozier, Maupin, Baumé, Bullion, to whom we owe a great number of valuable obſervations and advantageous proceſſes.

6. Till the epocha of the diſcovery of the decompoſition and nature of water, nothing was or could be done reſpecting the cauſe and the mechaniſm of the vinous fermentation. Since that epocha, one of the authors of this diſcovery, the illuſtrious Lavoiſier, began by a fine courſe of experiments upon this inteſtine commotion, to acquire a glimpſe of its ſource, its origin and the phenomena which give riſe to it. His reſearches upon this part of the ſcience, though ſtill imperfect, as he himſelf was aware, are among the fineſt monuments that have been raiſed to ſcience, and are to be reckoned amongſt the chefs-d'oeuvre of chemiſtry that have rendered this age and the French nation illuſtrious.

7. It has been by the aid of the firſt data of Lavoiſier, both upon the formation and the decompoſition of alcohol, that a ſeries of important diſcoveries have ſince been made relative to the action of this body, whether as a ſolvent, or a re-agent, or as acting by its intire maſs and in its perfect integrity, or as becoming altered and decompoſed. Thirty years had ſcarcely elapſed

from the period when the moſt able chemiſts, Rouelle, and Macquer, conſidered, with juſtice at that time, the vinous fermentation as one of the moſt impenetrable myſteries of Nature, as a ſort of ſanctuary in which ſhe deeply concealed one of her ſecrets, till the time when the ſcience ſucceeded, almoſt all at once, in explaining this moſt myſterious phenomenon, in reſolving this intricate and difficult problem, and reducing to ſimple laws this obſcure and till then unintelligible mechaniſm.

8. Since that time a multitude of truths, which had before been myſterious, reſpecting the properties of alcohol, its lightneſs, its inflammability, its brilliant flame without ſmoke, its converſion into ether, in a word, reſpecting whatever had till then been the moſt difficult and the leaſt underſtood in chemiſtry, became ſimple facts, phenomena eaſy to be explained, the preciſe reſults of an acquired firſt truth. The diſcovery of Lavoiſier ſuddenly appeared as a pharos, which has illuminated a vaſt tract enveloped before in darkneſs, and has rendered this branch of the ſciences, though imperfect and weak before his time, much more vigorous and much more rapid in its progreſs than could have been hoped, All the details which this article will comprehend, will demonſtrate the certainty of this propoſition.

SECTION II.

Conditions of the Vinous Fermentation.

9. THE conditions of the vinous fermentation are the circumſtances neceſſary to its formation, and without which it could not take place; when once known, nothing more is requiſite than to effectuate their production and combination, in order to excite this movement; or on the other hand, to deſtroy them, or prevent their taking place, in order to ſtop the fermentation, to preſent an obſtacle to its development. It will ſoon appear that one or the other of theſe circumſtances is actually employed in order to modify, ſuppreſs, accelerate or retard, promote or impede the vinous fermentation, and thus to give riſe to more or leſs important differences in the wines.

10. The firſt indiſpenſable condition is the preſence of ſaccharine matter. All the obſervations combine to prove that this vegetable matter alone is capable of undergoing the vinous fermentation, that without it we ſhould never obtain wine, and that all the vegetable liquids which contain it undergo this fermentation more or leſs eaſily and powerfully. Accordingly all the juices of ſaccharine fruits, and eſpecially the juice of the ſugar cane, that of the grape,

of figs, of cherries, of plums, of apricots, of apples and of pears, paſs, when all the other circumſtances of which I am about to ſpeak are combined, into the vinous fermentation, however different in other reſpects they may be; accordingly alſo the not-ſaccharine vegetable matters become ſuſceptible of affording wine only when, by the previous ſaccharine fermentation, there has been produced in them a more or leſs conſiderable quantity of ſaccharine ſubſtance, as in barley, maize, &c. For this reaſon I have placed the ſaccharine in the firſt rank amongſt the fermentations.

11. Sugar, however, whilſt inſulated and pure, never undergoes the inteſtine movement which is to convert it into wine. Every one knows that whilſt ſolid and cryſtallized it is abſolutely unalterable, and remains in this ſtate without undergoing any kind of change. Pure ſyrup is in the ſame predicament, and though water is one of the indiſpenſable and neceſſary conditions of the production of the vinous fermentation, water and ſugar, combined with each other, never preſent the phenomena which accompany this movement, nor afford its product. This is a fact at preſent well aſcertained by exact experiments, and which reſults particularly from thoſe of the brothers Boucherie, who have made many important and accurate obſervations upon this matter in the ſugar-refinery of Bercy, near Paris.

12. The proportion of water is one of the eſſential conditions of the vinous fermentation; in order to experience it, it is neceſſary that the ſaccharine matter ſhould be diſſolved and ſufficiently liquid; too much liquid however is detrimental to it, and frequently cauſes it to paſs beyond the term of this movement, by making it paſs quickly into that which ſucceeds it; too much viſcidity is equally unfavourable to it, and prevents its taking place: accordingly when the liquid deſtined to form the wine is too thick, it is proper to add water to it; and when it is too fluid, ſugar or any ſaccharine matter which gives it a ſtronger conſiſtence is added.

13. A ſomewhat elevated temperature is alſo requiſite for the production of this movement. The vinous fermentation never eſtabliſhes itſelf below 12 degrees of Reaumur's thermometer; it begins at this temperature and proceeds rapidly at ſixteen; it is too rapid above twenty, and then requires to be conducted with caution and management in order to prevent its going beyond the production of wine. When the climate or the ſeaſon are too cold, artificial heat is applied; in the oppoſite circumſtances the fermenting matters muſt be placed in the ſhade and in low ſituations.

14. I have remarked that ſugar and water alone can never undergo the vinous fermentation; in fact, it is eſſentially neceſſary that ſome foreign matters ſhould be added to them; and this is

what we ſee in all the juices of fruits which are ſubjected to it. They all contain, beſides the ſugar and water, mucilage, fecula, colouring matters, acids, acidules, and ſalts. This is the reaſon why even the pharmaceutical ſyrups, which ſometimes contain a ſmall proportion of ſubſtances foreign to the ſugar and water, ferment; but when they are abundantly charged with them, they paſs much more quickly into this fermentation, and are more difficult to be kept. It appears that any matter, capable of dividing the ſaccharine liquid, is ſufficient for acting as a ferment; and that it does not require to be of a particular nature, or to have already undergone the vinous fermentation in order to communicate this movement. It is on this account that, beſides the well known property of all the ſaccharine and mixed vegetable liquors to experience the vinous fermentation ſpontaneouſly, ſaliva, milk, and even fleſh, are frequently found to be capable of exciting and accelerating this fermentation in the vegetable liquors.

15. A large maſs, a large volume, greatly favour the production and the energy of the vinous fermentation; in general, the larger the vats are in which wine is prepared, the better quality the wine is obſerved to acquire; a ſmall quantity of ſaccharine liquor never experiences, or enters only with difficulty into this kind of fermentation, whereas it paſſes very quickly into the acid fermentation: we ſhall ſoon ſee upon what this difference depends.

16. The contact of the air has been conſidered by almoſt all chemiſts as one of the indiſpenſable conditions of the vinous fermentation; it ſerves however only as a reſervoir or recipient into which the carbonic acid which is diſengaged raiſes itſelf. It is not by its peculiar chemical nature that the air is of utility; it does not enter as an element into the fermenting liquor: hence this fermentation takes place in cloſe veſſels, provided with tubes which conduct the gas that is diſengaged into a reſervoir deſtined for this purpoſe, as has been ſhown by Lavoiſier. But if the matter that ought to ferment be ſtrongly compreſſed, if, inſtead of enjoying the free contact of the air, or having a tube to ſerve as a conductor for the gas, it is incloſed under covers which entirely prevent the eſcape of the elaſtic fluid, no fermentation, or only an imperfect fermentation takes place, becauſe there is then no gaſeous extrication.

SECTION III.

Phenomena of the Vinous Fermentation.

17. AS ſoon as fermentation eſtabliſhes itſelf in a ſaccharine vegetable matter, diluted with water, mixed with one or more other ſubſtances, and placed under all the circumſtances or conditions neceſſary to its exiſtence, of which

we have juſt ſpoken, its origin, its ſtate and its termination take place in a ſeries of phenomena which not only belong peculiarly to it and characterize it, but alſo become to the obſerver certain indications of its progreſs and its modifications. It is therefore of importance that we ſhould accurately deſcribe theſe phenomena, ſince, beſides the eſtimable advantages which I have juſt announced, they may alſo guide the philoſopher in the inveſtigation of the cauſes of the vinous fermentation.

18. This fermentation commences after ſome hours or ſome days, according to the elevation of temperature to which the ſaccharine vegetable liquors are expoſed, or according to the quantity of theſe matters: it announces itſelf by a movement which agitates the liquor, which ſucceſſively diſplaces its maſſes, which tranſports in its continuity the ſolid ſubſtances, the huſks, the ſtalks, and the ſeeds, and moves them in the liquid. The fermenting liquors become heated to eighteen or twenty degrees; they become turbid; we ſee in them, when the operation is carried on in a well-lighted place, or in tranſparent veſſels, as in experiments upon a ſmall ſcale, ſtreaks of an oily appearance, which ſeem to have a tendency to ſeparate from the liquid, and to occupy its ſuperior part. We ſhould be inclined to ſay that the liquors divide themſelves into two diſtinct ſpecies, which ſeparate from each other.

19. The fermenting liquors increaſe ſenſibly in volume, and raiſe themſelves in the vats; they become covered with a ſcum, ſometimes very voluminous, which carries along with it all the extraneous and ſolid bodies: this is what is called the head in the vats in which the wine is made. This ſcum is produced, as well as the riſing of the whole fermenting maſs, by the diſengagement of the carbonic acid gas, which however adheres for ſome time to the ſtill viſcid liquor, which attaches itſelf during its diſengagement to the ſolid matters mixed with this liquor, and raiſes them along with it; which, ſoon becoming free, fills the upper part of the vats, and forms that atmoſphere pernicious to thoſe who tread the vintage without due precaution, in which Prieſtley and Chaulnes firſt made the intereſting experiments quoted upon a former occaſion, the reſult of which is, that this gas is of the ſame nature as that which is obtained from chalk and the alkalis by efferveſcence,—which is formed by the combuſtion of charcoal,—which fills the Grotto del Cano,—and which mineralizes the acidulous waters, on that account called *ſpirituous waters:* in ſhort, it is pure carbonic acid, carrying along with it water, and even a ſmall quantity of wine in ſolution.

20. The quantity of carbonic acid gas diſengaged in this operation is very conſiderable; its diſengagement commences at the moment when the vinous fermentation eſtabliſhes itſelf,

and continues till the wine is entirely formed. In order that this liquor may be as ſtrong and alcoliferous as poſſible, this gas muſt be ſuffered to be entirely diſengaged: when the wine is drawn off before its complete diſengagement, ſparkling wine *(vin mouſſeux)* as it is called, and ſuch as has not undergone its complete fermention, is obtained. It is to a portion of wine in the form of vapour which this gas carries off in ſolution, eſpecially at the end of its diſengagement, that it owes the property which it poſſeſſes, of being converted into vinegar when it is diſſolved in water, according to the intereſting obſervation of Citizen Chaptal. From this gas alſo proceed the aſphixia to which perſons are expoſed who deſcend imprudently, and too deep into the vats to tread the grapes. We may aſcertain the height to which it elevates itſelf by plunging lighted tapers into the upper part of the vats; in deſcending into them the operator muſt keep his head above this height. It will be ſeen hereafter that this abundant production of carbonic acid during fermentation is one of the circumſtances from which Lavoiſier has derived the moſt light in his inveſtigation of the mechaniſm of this beautiful operation.

21. In proportion as all theſe phenomena take place, the liquor, more and more ſwelled, foaming, agitated, heated, even hiſſing in conſequence of the diſengagement of carbonic acid (on which account it is ſaid to boil), ſoon

changes its nature. From being mild and ſaccharine before, it now becomes acrid, pungent, and hot; from its former viſcid and glutinous ſtate, it paſſes into a very liquid and light ſtate; it diminiſhes in volume, it cools, its ſcum diſappears; the extraneous ſubſtances which had raiſed themſelves to its ſurface precipitate and are depoſited at the bottom; the liquor clears, and the wine is made. It is then drawn off from the vats, and put into caſks. After the wine, the carbonic acid runs off; it ſinks in the vat in proportion as the wine itſelf ſinks and yields its place to it.

22. The vinous fermentations preſent a multitude of varieties in the force, the rapidity, and the duration of the phenomena, which have juſt been deſcribed, according to a great number of different circumſtances, in which the fermenting ſubſtances are ſituated. The nature of the different vegetable juices, their more or leſs viſcid, thick and ſaccharine, or liquid and little ſaccharine ſtate; the ripeneſs of the fruit; the temperature, the place, the form of the veſſels, the quantity of the liquid, the admixture of extraneous bodies in greater or leſs abundance, ſuch as the ſtalks, the huſks, the ſeeds, all produce modifications which are conſidered with great attention in the art of making wine, cyder, beer, the wine of the ſugar-cane, &c. A too low degree of temperature renders the fermentation languid; a too little ſaccharine liquor, ſuch as is obtained from the

unripe fruits in rainy ſeaſons, affords a weak wine, ferments badly, and frequently turns ſour. This is corrected by evaporating part of it, or by adding ſome ſugar to it, which it wants; a too viſcid liquor requires the addition of water.

SECTION IV.

Of the immediate Product of the Vinous Fermentation, or of Wine.

23. IT cannot here be expected that we ſhould give a detailed hiſtory of the art of making wines, or ſhow in all their details the differences of the varied and multiplied ſpecies of wines, deſcribe their good and bad qualities, their depravations or alterations, the means of correcting and preſerving them. Theſe objects, which are all of great importance, are not comprehended in the general theory of the ſcience: they belong to its applications. I muſt here treat of what may have a reference to them, only in a very curſory manner, and under the moſt general point of view. The knowledge of this immediate product of the vinous fermentation, and what may throw a light upon its analyſis and its compoſition, belongs alone to the elements of the ſcience. I

ſhall therefore ſpeak of wine only with reference to its general differences, its analyſis, and its uſes.

A. *Of the principal Wines.*

24. EVERY one knows that no product of the arts varies ſo much as wine; that every province in which the vine is cultivated has its particular wine, frequently diſtinguiſhable, and well characterized by its taſte and its ſmell; that the manner of making it contributes much to this, though in general we are more induced to attribute its differences to the ſoil and the cultivation than to the fabrication itſelf; that it would be ſuperfluous and even impoſſible to deſignate, by a particular deſcription, the innumerable varieties which this liquor preſents, even in the extent of the French Republic alone, of all the countries of the earth the moſt opulent in wines, and thoſe of the beſt kind. We can therefore here treat only of ſome generalities, and of thoſe which are the moſt important reſpecting the differences of wines from each other; and thoſe eſpecially which proceed from the different vegetables with which they are prepared, will more particularly engage our attention on account of their importance.

25. The beſt and moſt admired wines are thoſe prepared from the juice of the grape. The property which this juice poſſeſſes

of forming the beſt wines that are known, does not depend upon its containing the moſt of ſaccharine matter; for in this point of view the ſugar-cane ought to afford it, but upon its principles being united together in ſuch a manner, that there reſults from them the moſt homogeneous, the moſt uniform, and the moſt agreeable combination that can exiſt, that which is the moſt univerſally pleaſing to mankind. Wines are diſtinguiſhed into red and white: the firſt colour proceeds from the circumſtance that the wines, having ſtood in the vats for a long time, have extracted all the colouring matter of the huſks of the grape; the ſecond kind of wines are frequently prepared with coloured grapes, but the liquor is drawn off before it has acquired the tinge. Beſides the general circumſtances of the vinous fermentation already mentioned, it is to be obſerved, that each kind of grape has its own peculiar manner of fermenting; that its juice is ſeparated when we wiſh to prepare fine wine; that it is left to work in the vats for a longer or ſhorter ſpace of time before it is put into caſks; that it ſtill continues to ferment in theſe veſſels, and to aſſume the quality of perfect wine; that it is ſubject to a great number of modifications; that it depoſits tartar; that its colouring matter ſeparates by degrees, and adheres to the ſides of the veſſels, or combines with the ſugar; that it keeps more or leſs according to its ſtrength and conſiſtence; that ſometimes, when it is very generous, it may be kept for many years; that its quality improves by this keeping, as far as a certain term, and that afterwards it deteriorates and loſes continually, till its total decompoſition.

26. It will be of utility to give a general notion of the ſpecific differences of wines. France produces a great number that are excellent. Thoſe called Burgundy wines are the beſt for general uſe; their principles are perfectly combined, and none of them predominates; they improve greatly in quality during ſix or eight years, after which they deteriorate, but very ſlowly, and in general they keep very well. The Orleans wines, as they are called, have qualities very ſimilar to thoſe of the Burgundy wines, when time has diſſipated their tartneſs, and intimately combined their principles. The red wines of *(ci-devant)* Champagne are very delicate; the white wine, which does not ſparkle, is greatly preferable to that which does, which is not ſufficiently mature, has not ſufficiently fermented, contains little or no alcohol, and becomes flat when it has loſt its carbonic acid. The wines of *(ci-devant)* Languedoc and Guyenne, are of a deep colour, and very tonic, eſpecially when they are old. Thoſe of *(ci-devant)* Anjou are very ſpirituous, and ſoon intoxicate. The German wines, thoſe of the Rhine and the Moſelle, are white, and very full of alcohol; they keep for a long time; ſome Italian wines, thoſe

of Orviette, of Vicenza, the *lachryma Chriſti*, are well fermented, and conſiderably reſemble the good wines of France. Thoſe of Spain and Greece are in general dry, ſweet, little fermented, and unwholeſome, excepting thoſe of Rota and Alicant, which are reckoned very uſeful cordials. The wines of the Cape of Good Hope are perhaps the firſt and beſt of all wines.

27. Sour and harſh apples and pears contain a juice which ferments pretty well, and which affords cider and perry. When cider is left to ſtand upon the lees it acquires ſtrength; when it is drawn off clear, the fineſt cider is formed; by adding to it freſh apple-juice ſweet cider is made, which continues to ferment, and contains much carbonic acid. This liquor reſembles wine in ſome of its properties; it differs from it, however, by its containing leſs tartar and much ſaccharine mucous ſubſtance, which is eaſily extracted from it by evaporation. It is on that account that when cider is diſtilled, without due precaution, an empyreumatic ſpirit of bad quality is obtained. But a cautious diſtillation, in which care is taken not to burn the reſiduum, furniſhes a very good brandy, according to the experiments of Citizen Darcet. It is known that the ſweet apples afford only flat cider, which is very ſubject to alteration.

28. Cherries alſo furniſh, by fermentation, a ſpecies of wine from which the kind of aqua-

vitæ known by the name of *Kirchenwaſſer* is extracted by diſtillation. Apricots, peaches, plums, alſo form wines which are not deficient in quality when they are well prepared. The juice of figs, diluted with water, likewiſe affords a very ſtrong and very generous wine, which however is not made, becauſe in the countries where figs abound they have very good vines. The juice of ſeveral ſpecies of the palm likewiſe ferments and affords a very intoxicating vinous liquor which is uſed in the Eaſt. The juice of the ſugar-cane, whilſt ſtill impure and diluted with water, undergoes a great fermentation, and affords a wine too ſtrong and too acrid to be drank in this ſtate, but it furniſhes a very ſtrong ſpirit, which in our colonies is called rum, taffia, or guildive. Thus we ſee that the number of ſaccharine vegetable ſubſtances capable of forming wine is very conſiderable; and every country may produce different wines, according to the kinds of plants which its ſoil bears and nouriſhes.

29. The ſeeds of the graminaceous plants, germinated and ſteeped in water after their fermentation, afford vinous liquors more or leſs eaſily and abundantly. Barley is principally employed for this purpoſe, though we may alſo uſe wheat, maize, and rye. Even rice affords in the Eaſt that kind of alcoholic liquor which is known by the name of arrack. The art of brewing conſiſts in the following proceſſes: The barley is ſteeped for thirty or forty hours in

water in order to ſoften it; this barley is laid in a heap, and ſuffered to germinate; it is afterwards dried in the *touraille*, or a ſquare furnace terminated by a *tremie*, upon which the germinated barley is ſpread out; it is ſifted in order to ſeparate the germs that have ſprouted out of the grains, and which are called *touraillons;* it is ground into a farina called *malt;* this farina is diluted in the meſhing tun with hot water, which diſſolves the ſaccharine mucilage: this ſolution is called the firſt wort; it is poured again upon the malt after it has been heated, and then it forms the ſecond wort; it is boiled for ſome time, and put to ferment with hops and yeaſt in a veſſel called the fermenting back. When the fermentation has ſubſided, it is agitated, or the beer is then drawn off into caſks: the ſecondary fermentation, or that which ſucceeds the firſt, raiſes from it a ſcum called yeaſt *(levure)*, which ſerves to excite the fermentation of the decoction of barley in the *cuve guilloire.*

B. *Of the Analyſis of Wine.*

30. HOWEVER different the various ſpecies of wine which I have mentioned may be, they nevertheleſs all reſemble each other in their general properties, and in the manner in which they comport themſelves in the analyſis to which they are ſubjected. They are always liquors more or leſs

coloured, of a pungent and hot taſte, of a more or leſs aromatic odour, which revive and invigorate in ſmall doſes, and in larger doſes produce that confuſion, agitation, and uncertainty in the ideas and motions of animals which is called drunkenneſs. They all contain a common and identical principle, from which their ſimilar effects proceed.

31. In fact, all wines equally afford, by the action of fire, that acrid and inflammable liquor which is called brandy, and which differs from them only by its proportion, the facility or difficulty of its diſengagement, and its particular odour which ſerves to diſtinguiſh the kind of wine which furniſhes it. They alſo differ in the proportion of tartar, which they however all contain, or of which at leaſt but very few of them are entirely deſtitute; they differ alſo in the quantity and nature of the extractive colouring parts; and ſome of them are more or leſs abundantly charged with mucous matter: it is this which eſpecially diſtinguiſhes the wine of apples, of pears, of cherries, of barley, or the ciders and beers.

32. Taking true wine, or the wine of the grape, as the example, it is a compound of a large quantity of water, of a volatile and inflammable matter, very analogous in its nature to alcohol, though without being ſuch, of tartar in different proportions, of an oxigenated extractive colouring matter, and of a more or leſs conſiderable proportion of vegetable acids. This compound combines in all proportions with

water, though it is frequently lighter, and tends to ſwim above it. It unites without decompoſition with many ſubſtances, and eſpecially with ſome metals which it attacks, and with almoſt all the metallic oxides, as is proved by the pharmaceutical operations by which the antimoniated or *emetic* wine, and the ferruginous or *chalybeate* wine are prepared. It diſſolves many vegetable ſubſtances, the mucilages, the extracts, the colouring parts; it is in this manner that the medicated wines are prepared, ſuch as the ſcillitic, the aſtringent, the antiſcorbutic, the laudanum of Sydenham.

33. All the acids brighten the colour of wine, which is owing in part to the preſence of one of theſe bodies; the alkalis render it darker, and give it more or leſs of a violet caſt. Alum is frequently combined with it, in order to render it more durable: the preſence of this ſalt is diſcovered by the addition of alkalis, which ſeparate from it alumine of a violet colour, a kind of lake. Frequently alſo its ſourneſs is ſoftened with alkali or chalk. This baſe is diſcovered in the ſtate of lime in its extract when burned. The moſt dangerous combination which is made with wine, in order to render it mild, and give it a ſaccharine taſte, is that of the oxides of lead. This liquor produces the painter's colic, or the colic of Poictou. The preſence of this metal may be aſcertained by means of water charged with ſulphurated hidrogen, which I firſt propoſed fifteen years ago, and is much preferable

to the alkaline ſulphurets, the effect of which is uncertain and deceptive, on account of the natural acids of the wines which precipitate them; whereas the ſulphurated hidrogen is precipitated only by the metallic oxides. We may alſo convince ourſelves of the preſence of lead in a ſtill more poſitive manner by heating the extract of the wine ſtrongly in a crucible, which produces globules of this metal. When we have to judge of a *lithargyrated* wine, as it is called, we ought not to content ourſelves with the precipitate which it forms with ſulphurated water; but we ſhould treat its reſiduum by fuſion. The preſence of copper, the green oxide of which wine alſo diſſolves very eaſily and abundantly, is demonſtrated by means of a bar of iron, which ſeparates from it the metallic copper with which this bar is ſoon covered.

34. The moſt frequent and the moſt uſeful analyſis which is performed upon wine, conſiſts in treating it by ebullition in a diſtilling apparatus. It then affords a liquid product known by the name of *brandy.* In the chemical laboratories it is diſtilled in an alembic of tinned copper, to which a receiver is adapted, and care is taken to cool the capital by keeping it continually ſurrounded with cold water. As ſoon as the wine boils in the alembic, a white, ſlightly opaque, and milky liquid, paſſes over in uninterrupted drops very cloſe to each other, of a pungent and hot taſte, of a ſtrong and pleaſant ſmell, and inflammable: this is the

brandy. The operation is continued till this product ceaſes to be inflammable and pungent, and till the period when nothing more than acidulous water is condenſed. If the operation be continued, water charged with a little acetous acid is obtained. There remains in the diſtilling veſſel a liquor of a deep red colour, which has no longer the taſte of wine, but which, on the contrary, is acid and auſtere, turbid and entirely filled with cryſtals of tartar, that ſeparate from it. This fluid is then entirely decompoſed; its original properties can no more be reſtored to it; it has a ſour taſte. By evaporating it ſtill more it is reduced to an extract of a browniſh red colour, which leaves much tartar after its diſcoloration.

35. The diſtillation of wine is performed upon a large ſcale, in order to obtain the brandy, in the countries where this liquor, being very abundant, is at the ſame time very generous or very ſtrong; eſpecially in ſeveral of the ſouthern departments of the Republic, particularly in the departments belonging to what was formerly the province of Languedoc. This fine diſcovery we owe to Arnaud de Villeneuve, a chemiſt of thoſe countries, who lived in the thirteenth century. Formerly the wine was there diſtilled or burned in an alembic of copper, ſurmounted with a long narrow cylindrical neck, terminated in a hollow hemiſphere in which the vapours were condenſed: this kind of capital had a beak or a tube of little width, which received

the liquor, and conducted it into a worm. The firſt alteration which was made upon this apparatus was the diminution of the length of the neck; afterwards the cucurbits were made wider, though it has long been uſual to contract their upper part, and to terminate it by a neck, to which was ſoldered, at the top, a capital in the form of an inverted cone, having at its ſuperior part a ſmall beak, which conducted the vapours through the worm incloſed in a tub. Theſe machines had a great many defects by their contraction, which cauſed much vapour to fall back,—by the height of the cucurbit, which cauſed the bottom of the wine to burn,—by the conſtruction of the furnaces which heated badly and unequally, and by the form of the capital, which repels the vapour, and cauſes that which is elevated to flow back.

36. According to the laſt method adopted by Citizen Chaptal, who has eſtabliſhed with great ſagacity ſome important chemical manufactures at Montpelier, we ought to employ boilers of greater width than height; their bottom is preſſed inwards, in order that the fire may act equally upon all points of the liquor; they are but very little contracted at the top, and only in order to receive a wide capital ſurrounded with its refrigeratory; they are provided with a groove, or channel, projecting half a decimetre, and its ſides inclined at an angle of ſeventy-five degrees, becauſe this inclination favours the flowing down of the condenſed brandy; the beak of this

capital is ſurrounded with a refrigeratory, from which the liquid inceſſantly runs off and remains always cool: a cock ſupercedes the neceſſity of a worm in this apparatus; and the operation produces brandy in abundance: from about one fifth to one fourth of the weight of the wine is obtained. All the modern diſtilleries are eſtabliſhed upon the ſame principles, and they afford a product of greater purity than was formerly obtained.

37. The brandy, in the proceſs that has juſt been deſcribed, is not diſengaged from the wine till the moment when the fluid boils, and at the period when it is profoundly decompoſed; it is therefore evident that it is not intirely formed or contained in it, as it requires this conſiderably elevated temperature, not only in order to diſengage it, but alſo to complete the combination of its principles. In fact, wine treated in balneo mariæ affords only a little fragrant water but no alcohol; and it is even in this manner that natural and pure wine is diſtinguiſhed from that which is artificially formed by a combination of brandy and different ingredients, or from that to which this liquor has been added in order to increaſe its ſtrength. Theſe at the heat of the balneum mariæ and without requiring to be boiled, give out the ready-formed brandy which has been added to them.

38. It is eſpecially by the different proportion of this product, called ſpirituous or alcoholic, that wines differ moſt from one another; much more is obtained from the wines of the

ſouthern department of the (ci-devant) Languedoc, Guyenne and Rouſſillon, than from thoſe of the central department, belonging to what were formerly called Burgundy and Champagne. The wine of the ſugar-cane or of the highly ſaccharine juices afford a great abundance of it, and it is even particularly prepared for diſtilling rum from it. A conſiderable quantity is alſo obtained from good cider and even from ſtrong beer, when diſtilled with precaution: theſe brandies are pretty good. The green and ſour wines, made in general with unripe grapes, afford only a weak brandy and in ſmall quantity. The ſparkling wines, charged with carbonic acid, the fermentation of which has been ſtopped before its completion, afford little or none. For the reſt, many experiments are ſtill wanting in order to give us a thorough knowledge of the different ſpecies of wine with reſpect to the brandy which they are able to yield, and many attempts yet to be made in order to extract it from fermenteſcible vegetables that have either not been tried at all or only in an imperfect manner.

39. Frequently only the lees, formed of tartar and extractive matter, depoſited and impregnated with vinous liquor, are diſtilled in order to extract the brandy from them. Frequently alſo only the wines that are already changed, that have begun to ſpoil, to turn ſour, and are no longer fit to be drank, are diſtilled. The lees are alſo uſed for obtaining pot-aſh: after having extracted the brandy from them by diſtillation,

they are burned in the open air or in furnaces; the tartarous acid is decompoſed; the combuſtion or the incineration is carried ſo far as to burn all the coal, and to reduce the aſhes to the ſtate of cauſtic pot-aſh and of carbonate of pot-aſh. This ſort of alkali is known in the arts by the name of pearl-aſh (cendres graveleés). When analyzed with attention, we find in it, beſides the cauſtic pot-aſh and the carbonate of pot-aſh, a ſmall quantity of ſulphate of pot-aſh, of ſulphate of lime, of oxide of iron and of mangaueſe. Theſe four ſubſtances are all contained in the wines, but they vary greatly in them with reſpect to their quantity. There are ſome pearl-aſh which contain no metallic oxides, whilſt others contain only the two ſulphates which I have mentioned.

40. Brandy, which is ſcarcely any thing elſe than water charged with alcohol, ſoon ceaſes to be this ſimple combination, on account of the proceſſes which are employed for preſerving it. As ſoon as it is obtained it is put into caſks of freſh oak-wood; the liquid acts very ſpeedily upon the wood, and diſſolves an extractive, colouring and reſinous matter, which gives it an amber colour, a ſlight taſte, and an aromatic odour, as well as a kind of conſiſtence ſomewhat unctuous or ſaponaceous, and the property of forming a durable froth at its ſurface by agitation: this is what is called in commerce *giving a bead.* This colouring matter of the brandy grows deeper by age, and it is

by its intenſity as well as by that of the unctuous quality that the age of the brandy is judged of. As old brandy is in great eſtimation, it has been found very eaſy to communicate ſpeedily to it the qualities which then characterize it, by throwing into this liquor, recently prepared, chips of oak-wood, from which it quickly takes up this colouring matter and this unctuous extractive. It is likewiſe from this extraneous matter that the portion of fawn-coloured or reddiſh extract proceeds, which Dubuiſſon has obtained from the reſiduum of brandy diſtilled in large quantities.

C. *Uſes.*

41. THE uſes of wines are ſo univerſally diffuſed, that it ſeems almoſt ſuperfluous to treat of them here in particular: accordingly I ſhall ſay but little concerning them under the relation of beverage. It is ſufficiently known that theſe liquors, which to the greater part of mankind have become an article of the firſt neceſſity, ſupport the ſtrength, increaſe the tone of the fibres, and the mobility and contractile force of the muſcles; but that their abuſe, to which men are ſo much inclined, produces great evils, and at length debilitates and even totally deſtroys the powers of digeſtion; that it gives riſe to lymphatic accumulations, to obſtructions and to dropſy. This remarkable effect of drunkenneſs is particularly known, the cauſe of which has as yet

been ſo little explained, and which the liquors produce, ſometimes with extraordinary celerity. It is particularly to be obſerved that this drunkenneſs with wine is not the ſame as that occaſioned by opium, by the *tòlium temulentum,* by the poiſonous plants in general, the *datura ſtramonium,* the *atropa mandragora, henbane,* conium *maculatitalum, ſolanum,* &c.

42. Wine is an excellent medicine for perſons who do not habitually make uſe of it; it is a tonic, a ſtomachic, a corroborant, a very powerful cordial. It is frequently employed as a vehicle or a recipient, for the preparation of a great number of pharmaceutical compounds. The abſurd practice of making medicinal vegetables ferment with the juice of the grape, with the intention of communicating to it the properties of thoſe plants by the fermentation itſelf, has long been laid aſide; it is now employed merely as a ſolvent, and thoſe ſpecies of wines are choſen that are beſt adapted to the nature of the qualities of the compounds which are wiſhed to be prepared with it. Wine is eſpecially and excluſively appropriated to the extraction of brandy, and this to the diſtillation of alcohol, the properties of which I am about to examine.

SECTION V.

Of the remote Product of the Vinous Fermentation, or of Alcohol.

A. Of the means of preparing it or extracting it from Brandy.

43. I CALL alcohol the remote product of the vinous fermentation, becauſe it has been ſeen that it is not contained ready formed in wine, that it is obtained from it only by decompoſing it by the heat of ebullition, and that it is really its remote product, or the reſult of a laſt analyſis. This liquor is one of the ſubſtances moſt uſeful to ſociety and to chemiſtry. Previous to the eſtabliſhment of the pneumatic doctrine, chemiſts had but a very imperfect knowledge, and erroneous ideas concerning it. Since Lavoiſier we have had a much more exact knowledge of it.

44. Brandy, which, as we have ſeen, is obtained by diſtilling wine by naked fire, is a compound of alcohol, of water and of a ſmall portion of oily and extractive matter, when it has remained for ſome time in caſks. In order to ſeparate theſe ſubſtances and obtain the pure alcohol, the action of fire and the proceſs of diſtillation are employed. There are ſeveral proceſſes

for obtaining the alcohol. Some chemiſts adviſe to diſtil the brandy in balneo mariæ a ſufficient number of times to extract from it all that it contains of this matter. They recommend to ſeparate the firſt quarter of the product of the firſt diſtillation, and likewiſe to ſet apart the firſt half of the product of the ſubſequent diſtillations, to mix together all theſe firſt products, and to rectify them by a gentle heat. The firſt half of the liquor which paſſes in this rectification is the moſt pure and moſt penetrating alcohol; the reſt is alcohol of leſs activity, but ſtill very good for ordinary uſes.

45. Rouelle directed to extract, by diſtillation in balneo mariæ, the half of the brandy employed. This firſt product is common alcohol; by rectifying it twice in ſucceſſion, and collecting only about two thirds of this firſt product, we obtain ſtronger alcohol, which is diſtilled again with water, according to the proceſs of Kunckel; the water ſeparates the alcohol from the oil which altered it; this alcohol thus diſtilled with the water is rectified, and we are then ſure of having it perfectly pure and as highly rectified as poſſible. The reſiduum of the diſtilled brandy is only water charged with extractive matter and a colouring reſin, covered alſo with a concreſcible kind of oil of which I have already ſpoken.

46. It is eaſily conceived that this fluid, according to the different proceſſes which are employed in preparing it, may have different degrees of purity. Means have long been ſought for

determining its purity. It was at firſt believed that the alcohol which eaſily takes fire and leaves no reſiduum was very pure ; but it is now known that the heat excited by its combuſtion is ſufficiently ſtrong to diſſipate all the water which it may contain. The teſt of gun-powder has long been employed. When the alcohol lighted in a ſpoon upon gun-powder did not inflame it, it was conſidered to be bad ; if on the contrary it ſet fire to it, it was ſuppoſed to be very good. This teſt however is faulty and deceptive ; for when much of the beſt alcohol is put upon little gun-powder, the water which it furniſhes in its combuſtion moiſtens the powder and it does not inflame ; whereas it may be inflamed by burning upon its ſurface a very ſmall quantity of alcohol charged with water. This mean was therefore not more certain than the firſt.

47. Boerhaave has given a very good proceſs for aſcertaining the purity of this fluid by the aid of fixed alkali. His method, if we adapt it to the preſent ſtate of the ſcience, conſiſts in throwing into the alcohol dry pot-aſh in powder. This ſalt unites with the ſuperabundant water of the alcohol, and it forms, whilſt it diſſolves in it, a heavier and more highly coloured fluid than the alcohol, which does not mix with it but ſwims at the top of it. We ſhall ſee that, in the true proceſs of Boerhaave, the pure alcohol diſſolved a part of the pure pot-aſh exiſting in the ordinary fixed alkali.

48. Several philoſophers, depending upon the circumſtance that alcohol is lighter than water in a degree proportionate to its purity, have contrived inſtruments called areometers, by means of which we may determine with ſufficient exactneſs the degree of purity or lightneſs of theſe fluids and of all volatile liquids. Theſe inſtruments, immerſed in alcohol, ſink in it the deeper the more highly this fluid is rectified; they ought to be conſtructed in ſuch a manner as to indicate at the ſame time the temperature of the liquor; otherwiſe they give only falſe notions of the weight of the alcohol. It is on this account that the areometer of Baumé is defective and not to be depended upon; that of Bories is more advantageous, ſince it indicates the temperature; accordingly it is that which is at preſent preferred by the dealers in brandy and ſpirituous liquors.

B. *Of the Phyſical Properties of Alcohol.*

49. ALCOHOL well prepared and well rectified is a tranſparent and very movable liquid, of a lively, penetrating and agreeable ſmell, of a hot, pungent, ſtimulating and acrid taſte, which ſeems even to burn the palate and the throat. It poſſeſſes the power of intoxicating in a much more energetic degree than wine. The cauſe of this very remarkable property is not known.

50. It is not enough to know that alcohol is lighter than water, it is neceſſary that we ſhould

determine with accuracy the relation of this weight. In the moſt highly rectified alcohol, it is to that of water as 8,293 to 10,000. In that of commerce, it is as 8,371 to 10,000. In the work of Citizen Briſſon on ſpecific gravities fifteen different weights are expreſſed according to the proportions of alcohol and of water from 1 to 15; they are preſented in the following order, pure or diſtilled water being ſuppoſed 10,000.

Alcohol.	Water.	Sp. Gravity.
Parts.	Parts.	
15	1	8,527
14	2	8,674
13	3	8,815
12	4	8,974
11	5	9,075
10	6	9,199
9	7	9,317
8	8	9,427
7	9	9,519
6	10	9,598
5	11	9,674
4	12	9,733
3	13	9,791
2	14	9,852
1	15	9,919

51. Alcohol is one of the moſt volatile ſubſtances which chemiſtry poſſeſſes, and this property accords with its ſingular lightneſs. It quickly evaporates in the air, which indeed unites its ſolvent property with the expanſibility of this liquid. When we heat it even ſlightly in cloſe veſſels, it is elevated, and paſſes without alteration into the receiver: it is by this means that it is rectified and ſeparated from the ſmall quantity of water which it might contain. Accordingly the firſt portions of this diſtilled liquid are the moſt pleaſant, the moſt aromatic and the pureſt. It was formerly believed that, in the diſtillation of alcohol, there was always diſengaged a large quantity of air: it is now known that this is the moſt volatile part which ſeparates from the water and paſſes into the ſtate of gas. It boils at 64 degrees, and is in violent ebullition at 68 of Reaumur. When kept in a cloſe veſſel immerſed in water at 72 degrees of temperature, it aſſumes the gaſeous form and retains it as long as the temperature remains at that elevation.

52. It is a much better conductor of caloric than water, it is much more dilatable than the latter; on which account it is employed in the conſtruction of thermometers: it is alſo a very good conductor of electricity.

C. *Of the Chemical Properties of Alcohol as ſolvent, and not decompoſed.*

53. In the expoſition of the numerous chemical properties of alcohol, I have found it uſeful to diſtinguiſh thoſe which it preſents in the integrity of its compoſition, or the combinations into which it enters intire; frequently as a ſolvent, ſometimes as diſſolved, from thoſe, or from the circumſtances in which it is more or leſs altered and decompoſed. Perhaps even this method might be adopted in the hiſtory of all the compound bodies. To the firſt properties belong the combinations of this inflammable liquid with the air, with ſulphur, phoſphorus, water, ſome acids, the alkalis, a conſiderable number of ſalts, and ſeveral metallic ſubſtances. I ſhall here treat of each of them in ſeparate numbers.

54. Alcohol expoſed to the air evaporates and diſſolves in it at a temperature of 10 degrees + 0; it leaves no reſiduum when it is highly rectified, and only ſome portions of water when it is leſs ſo; the more the temperature of the air is elevated, the more abundantly or ſpeedily it diſſolves in it; in proportion as this ſolution is effected, cold is produced upon the ſides of the veſſels from which the alcohol eſcapes. This may be very ſenſibly perceived by dipping the fingers in this liquid, and afterwards agitating them in the air; it is not known whether it has

more attraction for the oxigen than for the azotic gas.

55. Alcohol has no action upon ſolid or pulverized ſulphur, neither at the common temperature, nor at that which cauſes it to boil. But when theſe two ſubſtances meet together in vapour, they unite well with each other, and there reſults from them a fetid ſulphurated alcohol, which depoſits a little ſulphur, and becomes turbid in cooling, which is precipitated by water, and in which about a ſixtieth part of ſulphur is found; it diſſolves better the ſulphurated hidrogen gas which colours it a little, and which is decompoſed in this combination by the contact of oxigen gas, and all the oxigenated bodies, ſtill more quickly than when alone and in the ſtate of gas. Alcohol takes away the ſulphurated hidrogen from waters which contain it, by the aid of diſtillation.

56. Alcohol alſo diſſolves a ſmall quantity of phoſphorus by heat. This fetid ſolution is precipitated by the contact of water; it is very luminous when it is agitated in the dark. At the moment when it is poured into water in the night, brilliant luminous tufts exhale from its ſurface, and there is precipitated from it an oxide of phoſphorus in a white powder. Alcohol appears to be alſo ſuſceptible of diſſolving the phoſphorated hidrogen gas.

57. Alcohol unites with water in all proportions, and is perfectly ſoluble in it. This ſolution takes place with an extrication of heat,

and it forms kinds of factitious brandies, which are ſtronger in proportion as they contain alcohol in larger quantity. The affinity between theſe two fluids is ſo great, that water is capable of ſeparating alcohol from ſeveral ſubſtances that are united with it, and that alcohol reciprocally decompoſes moſt of the ſaline ſolutions, and precipitates the ſalts from them. It was on account of this property that Boulduc propoſed to employ alcohol for precipitating the ſalts contained in mineral waters, and for obtaining them without alteration. It is employed in a multitude of circumſtances. As the combination of alcohol and water takes place with a diſengagement of caloric, this combination is more denſe than the proportion of the two liquids indicates by the calculation of their ſpecific gravity. The alcohol is eaſily ſeparated from water by diſtillation; it paſſes firſt into vapour, and this is even, as I have already obſerved, a good means for ſeparating it from the oil which is combined with it in its ſtate of brandy.

58. Alcohol is capable of diſſolving only the weak acids, without experiencing alteration: it is in this manner that by the aid of heat, it diſſolves the boracic acid, which gives it the property of burning with a green flame. It alſo diſſolves the carbonic acid gas, which it condenſes and liquefies more than in the proportion of a volume equal to its own. It precipitates, on the contrary, the con-

centrated phoſphoric acid, from water, in a mucous or almoſt concrete form, as well as thoſe metallic acids which are ſoluble in the aqueous liquid.

59. No earthy baſes are known that are ſoluble in alcohol, but the alkalis combine with it very well. Pure or cauſtic pot-aſh and ſoda unite in a direct manner with alcohol, as is proved by the preparation that has long been known in pharmacy by the name of acrid tincture of tartar. In order to prepare this medicine, the pot-aſh was fuſed in a crucible; it was pulverized whilſt quite hot, it was put into a matraſs; alcohol was poured to the height of three or four finger breadths above the alkali; the matraſs was cloſed with another ſmaller one; they were luted together, and the whole digeſted in the ſand-bath till the alcohol had acquired a reddiſh colour. There remained more or leſs alkali at the bottom of the veſſel. All that was carbonate of pot-aſh did not diſſolve in it.

The too famous *lilium* of Paracelſus differed from the acrid tincture of tartar only by the circumſtance that the fixed alkali, which was employed for preparing it, was reduced to the ſtate of cauſticity by the ſtrong heat to which it was ſubjected. Equal parts of the three alloys, then called regulus of antimony, the martial, the jovial, and that of Venus, were mixed together; they were reduced to powder, they were made to detonate with one and a half times their weight of nitre, and as much tartar;

they were fuſed, this mixture was pulverized, it was put into a matraſs, and well purified alcohol was poured upon it till it roſe three or four finger breadths above it. This mixture, put to digeſt upon a ſand-bath, aſſumed a fine red colour, deeper than that of the *acrid tincture of tartar*, and it preſented the ſame phenomena. This latter might be prepared, intirely ſimilar to the *lilium* of Paracelſus, by digeſting the alcohol upon cauſtic fixed alkali, inſtead of employing fixed ſalt of tartar, which the action of the fire did not intirely deprive of carbonic acid, unleſs it was kept red hot for a long time.

Citizen Berthollet has aſcertained that theſe tinctures are only ſolutions of cauſtic pot-aſh in alcohol, and that they afford an uſeful means of obtaining this alkali very pure, by ſeparating it by evaporation.

Alcohol has the ſame action upon ſoda. By this ſolution we not only obtain very cauſtic fixed alkalis, in a very pure ſtate, (ſeparated from the ſilex, the alumine, and the neutral ſalts which are ſo frequently united with it after treatment by lime) by rapidly evaporating their alcoholic ſolution in a ſilver veſſel; but alſo by expoſing to the air and to ſlow refrigeration their ſaturated ſolution, it yields cryſtals of pot-aſh and of ſoda in fine white plates, or in regular priſms grouped together. This is the proceſs employed for obtaining theſe baſes, and the only one which gives them in the cryſtalline ſtate.

Ammonia combines with alcohol with an extrication of heat; it is ſeparated from it by the action of fire, as the ammonia forms a permanent gas; but it retains in gaſeous ſolution a ſmall quantity of alcohol, which modifies its ſmell and its properties.

60. Alcohol diſſolves ſeveral ſaline ſubſtances. Macquer firſt aſcertained that the ſulphates do not diſſolve in it without difficulty; that the nitrates and the muriates unite with it much better, and that in general alcohol diſſolves the ſaline ſubſtances the better in proportion as their acid has leſs adheſion with them.

Alcohol boiled upon the ſulphates of pot-aſh and of ſoda diſſolves no part of them. The carbonates of pot-aſh and of ſoda do not unite with it; theſe ſalts, inſoluble in alcohol, are even precipitated from water by this re-agent. Moſt of the ammoniacal ſalts diſſolve in alcohol. The deliqueſcent earthy ſalts eſpecially, ſuch as the calcareous and magneſian nitrates and muriates diſſolve in it abundantly. Bergman has even adviſed to employ it in order to ſeparate the deliqueſcent ſalt from the others by a firſt alcoholic lixiviation applied to the reſidues of mineral water: this proceſs may be employed to make ſome ſalts cryſtallize that are difficult to be obtained in their regular form.

A great number of metallic ſalts are alſo very ſoluble in alcohol; ſuch are eſpecially the red ſuper-oxigenated ſulphate of iron, or that in the ſtate of *mother water*, the nitrate of copper, the muriates of iron and of copper, the ſuper-oxigenated muriate of mercury or *corroſive ſublimate ;* all the cupreous ſalts give a very fine green colour to its flame. Since Macquer, Citizen Guyton has given, in the Journal de Phyſique, a more complete table of the degrees of ſolubility of the ſalts by alcohol.

61. Alcohol has no action upon the metallic matters, nor upon their oxides at leaſt without being decompoſed: we ſhall find hereafter that it is frequently decompoſed by the ſolutions of the metals in the acids; but this kind of action does not belong to the part of its hiſtory which we are now conſidering, and it will be retraced in that in which we ſhall have to treat of its decompoſition.

62. There are few vegetable matters upon which alcohol cannot exert a more or leſs marked action; but it is more conſiderable, according to the different nature of the immediate materials of the plants.

Margraff extracted, by means of alcohol, the ſaccharine matter of the beet-root, of ſkirret, of parſnips, &c. Since that time it has been extracted by the ſame proceſs from the ſtalks of maize, and from a great number of fruits.

The extractive matter diſſolves in it very well in general, and the better the more it is oxigenated. It conſtantly gives the alcohol a fawn or reddiſh colour.

The vegetable ſubſtances which unite the beſt with alcohol, are the volatile oils, camphor, the reſins, the balſams, and ſeveral colouring matters.

63. The improper name of diſtilled ſpirituous water is given to alcohol, charged by diſtillation with a ſmall quantity of volatile oil from the odorous vegetables: it has been thought that it united by this operation with a paricular principle of odour, which was called *ſpiritus rector*, or *aroma.* I ſhall prove that it is a ſmall quantity of oil which it carries along with it.

In order to obtain thoſe fluids, called *odorous ſpirits*, or *diſtilled ſpirituous waters*, the alcohol is diſtilled in *balneo mariæ* with odorous plants, or with their parts, chopped or pounded. This liquid carries off a portion of their volatile oil, and riſes with it; accordingly it has the property of being precipitated and becoming white with diſtilled water; a portion of this oil, which renders it acrid, and at the ſame time very fragrant, is ſeparated by rectifying it on the water-bath, with a very gentle heat, and taking care to draw off only three-fourths of the alcohol that has been employed, in order that we may be ſure to volatilize with it only the ſmall quantity of oil which is ſufficient for giving it the odour. The ſmall quantity which it then contains is ſoluble in the water that is added to it, ſo that no precipitation is now effected by the addition of this liquid. Theſe fragant alcohols acquire a more

agreeable

agreeable ſcent in proportion as they grow older, and it appears that the oily and odorous principles combine more and more intimately with the alcohol. The volatile oil has ſo much attraction for alcohol, that the latter is capable of taking it away from water. In fact, when alcohol is diſtilled upon water charged with the odour of a plant, the alcohol takes from it its fragrance, and leaves it entirely inodorous. A proof of this ſimple theory is, that *perfumed ſpirituous waters* are made by diſſolving ſome drops of volatile oil in alcohol, and this is the operation practiſed both by the perfumers, and in the laboratories where compound liquors are prepared.

64. We may charge alcohol with a much greater quantity of volatile oil by diſtillation; it then, beſides the odour, acquires an acrid and burning taſte; water poured into it precipitates the oil from it abundantly in white and opaque globules; but there remains, after this precipitation, the portion which the water can diſſolve, ſo that the liquor always retains a ſtrong odour. In general, the ſmall quantity of volatile oil, which is ſufficient for rendering alcohol odorous, adheres to it with great force, and it cannot be deprived of it by any known proceſs.

65. Alcohol eaſily diſſolves camphor in the cold; but it diſſolves a larger quantity when aſſiſted by heat. This ſolution, when well charged, as with a quarter of its weight

of camphor, mixed with water that is added to it by degrees and drop by drop, affords a cryſtalline vegetation, obſerved by Romieu; it is a perpendicular filament upon which are implanted needles that elevate themſelves againſt the filament, at an angle of 60 degrees. This experiment ſucceeds but very rarely, and requires great nicety with reſpect to the quantity of water, the refrigeration that is neceſſary, &c. Camphorated alcohol, united with a large quantity of water, depoſits the camphor in white concrete flakes, very pure and without alteration.

66. All the reſins are ſoluble by alcohol, but much leſs eaſily and abundantly than the volatile oils. Theſe reſinous ſolutions are thick, more or leſs tinged with a yellow, red or brown colour. Water decompoſes them immediately, and precipitates the reſins from them in fine white, opaque or ſlightly coloured globules.

The balſams diſſolve in alcohol like the reſins; when they are precipitated from it by water, their benzoic acid remains in ſolution, and only their reſinous part is depoſited.

The gum-reſins are only partially ſoluble in alcohol; and chemiſts have analyzed them by applying to them ſucceſſively this liquid and water.

Several colouring parts, not only the reſinous as has long been imagined, but alſo the oxigenated extractives, unite with alcohol, and colour it more or leſs ſtrongly: we may alſo ſeparate them from it by water, but frequently they remain united, at leaſt in part, with the mixture of theſe two liquids.

67. The names of *tinctures*, *elixirs*, *balſams*, *quinteſſences*, &c. have been given to the compounds of oily or reſinous juices and alcohol, when this is ſufficiently charged with theſe ſubſtances to have a high colour and to be abundantly precipitated by water. Theſe pharmaceutical preparations are, like the odorous aromatic alcohols, either ſimple when they contain only one matter in ſolution, or compound when they contain ſeveral at the ſame time. Theſe medicines are in general prepared by expoſing the juice in the ſtate of powder, or the dried plant, the volatile oil of which is to be diſſolved, the reſin, the balſam, or the colouring extract, to the action of the alcohol, which is aided by agitation and by the mild heat of the ſun or of a ſand bath. When it is wiſhed to extract the reſins of ſeveral plants or any kinds of vegetable ſubſtances at the ſame time, care is taken firſt to digeſt the matter that is the leaſt ſubject to be attacked by the alcohol, and to expoſe ſucceſſively to its action the ſubſtances that are the moſt ſoluble in it. When this ſolvent is as much charged as it can be, it is filtrated through paper; ſometimes a compound tincture is made immediately, by mixing ſeveral ſimple tinctures together; in this manner the *Elixir Proprietatis* is prepared, by combining the tinctures of myrrh, of ſaffron and of aloes. We may ſeparate the reſins and the balſams from the al-

cohol by pouring water into the tinctures or by diſtilling them; but in theſe two caſes the alcohol retains a portion of volatile oil which has been called the aromatic principle of theſe ſubſtances. Water is not capable of decompoſing the tinctures formed with what were called the extracto-reſinous or the reſino-extractives; that is to ſay, the highly oxigenated extractives, as we find in rhubarb, ſaffron, opium, gum-ammonia, &c. as theſe matters are equally ſoluble in theſe two liquids.

D. *Of the Chemical Properties which Alcohol preſents whilſt it becomes decompoſed.*

68. In a great number of chemical operations which are performed with alcohol, it comports itſelf in a very different manner from what has juſt been ſaid; it does not enter intire into the combinations: on the contrary, it is decompoſed or modified more or leſs completely, ſo far as to be reduced into its conſtituent elements ſeparated from each other: it is of this then I am now about to treat. I refer the chemical properties which produce different degrees of decompoſition in alcohol, to its treatment by a high temperature, its inflammation, its alteration by the acids, by the oxides or by the metallic ſolutions: the examination of the phenomena which it preſents in each of theſe circumſtances, conſtitutes one of the moſt important parts of modern chemiſtry.

69. When alcohol is paſſed through a red-hot tube of porcelain, it is decompoſed; water is obtained at the extremity, and the veſſel which receives its vapours has a burned or empyreumatic odour; there is alſo diſengaged a certain quantity of carbonated hidrogen gas and of carbonic acid gas. Some chemiſts aſſure us that in this operation an ethereal product is obtained, and in fact we can at leaſt perceive a fragrant odour analogous to that of ether. There are alſo conſtantly depoſited upon the ſides of the ball, ſmall white and brilliant cryſtals, which reſemble benzoic acid, but which have been aſcertained by Citizen Vauquelin to be a kind of concrete volatile oil. The tube of porcelain, broken after the operation, preſents a very fine black ſoot upon its ſides. This operation, which is very remarkable, has not yet been performed with ſufficient care to enable us to deſcribe all its circumſtances with accuracy and to determine its cauſe with preciſion. All that we ſee in a poſitive manner is that there is formed water and a little carbonic acid, that carbonated hidrogen gas is ſeparated, and carbon is depoſited. By inveſtigating with accuracy the nature and the proportion of theſe products of the incandeſcence of alcohol, a reſult will be obtained, of utility towards determining the nature and relative quantity of its primitive principles.

70. Alcohol has long been known to be a very inflammable ſubſtance: when heated in contact with the air, and eſpecially when brought into con-

tact with a body in the ſtate of combuſtion, without being itſelf heated, or if ſtruck by a ſtrong electric ſpark, it takes fire and burns with a very extenſive flame, which is very light, white in the middle, blue at its ſides, with a pretty ſtrong heat and without leaving any reſiduum. Chemiſts have long ſince remarked that it affords in its combuſtion neither ſoot nor ſmoke. Boerhaave, by preſenting a cold veſſel of porcelain to its flame had collected pure water, without taſte or ſmell, and in every reſpect ſimilar to diſtilled water; he had even concluded from this phenomenon that flame is owing to water in the ſtate of vapour.

Lavoiſier, by burning alcohol in a lamp placed under a receiver filled with atmoſpherical air, and communicating with another receiver filled with oxigen gas, ſo that this ſupplied the former with the oxigen requiſite for the combuſtion, obtained from ſixteen parts of alcohol thus burned, eighteen parts of water and of carbonic acid. Citizen Berthollet has alſo remarked that when alcohol mixed with water was burned, the portion of the latter which remained after the combuſtion precipitated lime-water; and as we find here no other reſults of this combuſtion than water and carbonic acid, it is thence inferred that alcohol is formed of hidrogen, carbon and a certain proportion of oxigen. The preſence and the quantity of the laſt mentioned principle is judged of by the portion of oxigen which it is neceſſary to employ in order to favour the combuſtion of the alcohol, compared with that of the water obtained. Lavoiſier has concluded from his experiments, that alcohol is a kind of oxide, in which the hidrogen is more abundant than in the ſugar from which it has proceeded. He has not however been able exactly to determine its proportions, ſince in his table of the products of the vinous fermentation, he admits more than the half of the alcohol of water ready formed in this liquid, and he does not clearly explain himſelf reſpecting the reciprocal ſtate of the principles which conſtitute it. Though ſtill far from exact, his analyſis by combuſtion is however ſufficient to prove that the ancient notions reſpecting the nature of alcohol are falſe, and that it is neceſſary to revert to that which I have already given concerning its ſtate of oxide. It is not therefore a combination of a very attenuated oil, an acid and water, a ſort of acid ſoap, as Stahl and Boerhaave had believed, nor, according to the opinion of Cartheuſer and Macquer, a pure or ſimple combination of water and of *phlogiſton* or of hidrogen; for the *phlogiſton* of Stahl has been converted into hidrogen by moſt of the modern chemiſts, who continue to adopt its exiſtence.

71. Though I have indicated the pure alkalis as ſimply ſoluble in alcohol, this ſimple ſolution without alteration takes place only in the cold, or at a mild temperature; for when this ſolution is ſtrongly heated in a retort with a convenient apparatus, we obtain products which indicate

the decompoſition of this inflammable ſubſtance: there paſſes over firſt an alcohol of an agreeable and aromatic ſmell, a ſort of oil, much hidrogen gas, and the pot-aſh which remains is charged with carbon. Some chemiſts have aſſerted that ammonia was diſengaged in this operation, and they have ſeen in it, as in the diſtillation of ſoap made by the ſame elevated temperature, a proof of the preſence of azote in pot-aſh. Others believe that it is only a ſmall quantity of pot-aſh elevated with the volatile products which has produced the change in this experiment. Hence, it reſults, that this operation is not yet well known, and that if it proves in general the decompoſition of the alcohol, it cannot yet ſerve for the determination of its principles, and ſtill leſs of thoſe of the pot-aſh.

72. All the powerful acids act upon alcohol in a more or leſs powerful manner, and affect its decompoſition with different phenomena, according to their energy, their quantity, and the temperature to which their mixture is expoſed. That which is of all the moſt important to be well known and its action well determined, ſince it will ſerve to explain that of all the others, is the concentrated ſulphuric acid.

When this acid is poured upon alcohol, it firſt ſinks to the bottom; by agitation it mixes with it, producing heat and a hiſſing that proceeds from a diſengagement of a portion of alcohol, already altered and aromatic, in the ſtate of vapour; the mixture aſſumes a brown colour, and left in this ſtate it forms what was formerly called *dulcified ſulphuric acid*, or *water of Rabel*, when a fourth of acid had been added to it.

When we place the retort in which the mixture is generally made upon a bath of heated ſand, and adapt two receivers to it, the firſt immerſed in a veſſel filled with cold water or ice, we obtain ſucceſſively,

a. An alcohol of an agreeable ſmell.

b. A liquid called ether, of a lively ſmell, of extreme volatility, the preſence of which is announced by the ebullition of the liquor contained in the retort, and by large ſtreaks that appear on the vault of this veſſel. Care is taken to cool the receiver with wet cloths.

c. After the ether, ſulphureous acid paſſes over, the white colour and the ſmell of which indicate that it is time to unlute the receiver, in order to have the ether ſeparate.

d. At the ſame time there is volatilized a light, yellowiſh oil, which is called *ſweet oil of wine*. The fire ought to be greatly moderated after the ether has paſſed over, as the matter contained in the retort is black, thick and ſwells conſiderably.

e. When all the ſweet oil is diſtilled, there ſtill paſſes over ſulphureous acid which becomes more and more thick, and is at laſt nothing more than black and impure ſulphuric acid.

f. It is accompanied with an odorous carbonated hidrogen gas and with carbonic acid gas.

g. It is to be obſerved that till concentrated ſulphuric acid paſſes over, water is conſtantly elevated at the ſame time with all the other products.

h. When this operation is continued with a mild fire, the reſiduum becomes at laſt intirely dried, and acquires the form and conſiſtence of a bitumen. An acid liquor and a ſubſtance dry and yellowiſh like ſulphur are obtained from this bitumen, by expoſing it to a very ſtrong fire. Citizen Baumé, who made a large ſeries of experiments upon the ſulphuric ether, long before the eſtabliſhment of the pneumatic doctrine, examined this reſiduum with much attention. He found in it ſulphate of iron, Pruſſian blue, a ſaline ſubſtance and a particular earth, the nature of which he has not determined; he aſſures us even that the yellowiſh ſublimate which it affords is not ſulphur, and that it remains white and pulverulent without inflaming upon the coals. I ſhall add to theſe details, that the reſiduum of the ether, collected after the diſtillation of this product, may again furniſh new ether if we add to it, according to the proceſs of Citizen Cadet, a third of alcohol dephlegmated by means of potaſh, and diſtil this mixture. Theſe diſtillations may be repeated ſeveral times, and thus may be extracted from a mixture of ſix parts of ſulphuric acid and of alcohol, to which fifteen parts of the latter fluid are ſucceſſively added, more than ten parts of very good ether.

73. The operation which I have juſt deſcribed is one of the moſt ſingular which chemiſtry affords, by the phenomena which it preſents, and at the ſame time one of the moſt important, by the light which it may throw upon the compoſition of ether. Several opinions have been advanced reſpecting the formation of ether, of which ſome account muſt be given, in order that it may be underſtood in what manner Citizen Vauquelin and myſelf have arrived at the diſcovery of the true cauſe of etherification. Macquer, who conſidered alcohol as a compound of water and of *phlogiſton*, thought that the ſulphuric acid carried off the water from this ſubſtance, and brought it more and more near to the characters of oil. Thus, according to this opinion, there firſt paſſed over alcohol little altered; afterwards a fluid intermediate between alcohol and oil. This was the ether; and finally a real oil, becauſe the ſulphuric acid was ſuppoſed to act with the greater energy upon the principles of the alcohol, in proportion as the heat employed for obtaining the ether was more intenſe. Bucquet, ſtruck by an objection which he had ſtarted againſt this theory, namely, that it was difficult to conceive how the ſulphuric acid, charged from the commencement of its action upon the alcohol with a certain quantity of water which it had taken from this fluid, could, although phlegmatic, re-act ſufficiently upon another portion of the ſame alcohol to reduce it to the ſtate of oil, has propoſed

poſed another opinion reſpecting the production of ether. With Stahl and Boerhaave, he conſidered alcohol as a fluid compoſed of oil, of acid and of water. He thought that when ſulphuric acid was mixed with alcohol, there reſulted from this mixture a ſort of bituminous fluid, which afforded the ſame principles, by the action of heat, as all the bitumens; that is to ſay, a light, highly odorous, very combuſtible oil, a kind of naphtha, which was the ether, a ſubſtance that has long borne the name of *naphtha*, amongſt the German chemiſts eſpecially, and afterwards an oil leſs volatile, and more highly coloured than the firſt, which was the ſweet oil of wine. In fact, it will be ſeen from the properties of ether that are about to be enunciated, that this fluid has all the characters of a very attenuated oil, ſuch as the naphtha: but this theory, which ſuppoſes alcohol to be formed of oil, of acid, and of water, can no longer be admitted, though ingenious at the time when it was propoſed, for the explanation of the mechaniſm of the formation of ether.

74. Modern chemiſts, ſince the eſtabliſhment of the pneumatic doctrine, have hitherto formed only vague ideas concerning etherification. I had aſſerted after them, in my preceding works, that it appeared, that the oxigen was taken away from the ſulpuric acid by the alcohol, that a part of the hidrogen of the latter formed water with the oxigen of the acid,

and that the alcohol deprived of this portion of hidrogen formed ether; but I had added, that what took place in this operation was not exactly known; and in fact, when Citizen Vauquelin and myſelf occupied ourſelves with this ſubject, we arrived at other reſults. The following is a ſketch of our labours upon this ſubject.

75. After having previouſly proved, as I have ſhown elſewhere, that the concentrated ſulphuric acid acts ſpontaneouſly upon the vegetable ſubſtances, changing them into water and acetous acid at the expenſe of their compounds, and exerting on its own part only its great tendency to ſaturate itſelf with water, we examined the phenomena which take place in the union of this acid with alcohol; and the following are thoſe which ſerved as the baſis of our reaſoning.

A. Equal parts of concentrated ſulphuric acid, and highly rectified alcohol, mixed together, diſengage a maſs of caloric capable of elevating the temperature of the mixture to ſeventy degrees; bubbles of gas are formed; the liquor becomes turbid, opaque, and aſſumes after ſome days a deep red colour.

B. A combination of two parts of ſulphuric acid, and one part of alcohol, elevates the temperature of the mixture to ſeventy-five degrees, becomes immediately of a deep red colour, paſſes to black ſome days after, and diffuſes an odour ſenſibly ethereal.

C. If we carefully obſerve all that takes place in the combination of equal parts of ſulphuric acid and of alcohol, expoſed to the action of caloric in a convenient apparatus, ſuch as is at preſent employed for preparing the ether we remark the following phenomena:

a. When the temperature is elevated to ſeventy-eight degrees, the liquor enters into ebullition; a vapour is produced, which is condenſed by the cold into a clear, light, and odorous liquid, which, on account of theſe properties, has received ths name of ether. When the operation is ſkilfully conducted, no permanent gas is developed till about half the alcohol is converted into ether.

b. If, as ſoon as the ſulphureous acid manifeſts itſelf, we change the receiver, it is obſerved that no more ether is formed, but ſweet oil of wine, water, acetous acid, and not an atom of carbonic acid.

When the ſulphuric acid forms about four-fifths of the maſs that remains in the retort, an inflammable gas is diſengaged, which has a ſmell of ether, and which burns with a white oily flame. It is this gas which the Dutch chemiſts have called *carbonated hidrogen gas*, or *olefying gas*, becauſe when mixed with the oxigenated muriatic acid it forms oil. At this period the temperature of the matter contained in the retort is elevated to eighty-eight or ninety degrees.

c. When the ſweet oil of wine ceaſes to run, if we change the receiver again, we ſee that there now paſſes over only ſulphureous gas, water previouſly formed, carbonic acid gas, and that there remains in the retort only a maſs, the greater part of which is ſulphuric acid thickened by coal.

From theſe phenomena, which are very conſtant, and have been well obſerved, we may draw the following reſults:

a. There is formed ſpontaneouſly, without the aid of adventitious heat, by the combination of two parts of ſulphuric acid, and one part of alcohol, a ſmall quantity of ether.

b. As ſoon as ether is formed, and at the ſame time water is produced, and whilſt the firſt of theſe compoſitions takes place, the ſulphuric acid undergoes no change in its intimate nature.

c. As ſoon as the ſulphureous acid appears, no more ether is formed, or at leaſt very little; but there then paſſes ſweet oil of wine, water, and acetous acid.

d. When the ſweet oil of wine has ceaſed to paſs, nothing more is obtained than ſulphureous acid, carbonic acid. and finally ſulphur, if we diſtil it to the end.

The operation of making ether, as it is practiſed, is therefore really divided into three epochas: the firſt, in which a ſmall quantity of ether and of water are formed without the aid of an adventitious heat, namely, between ſeventy and ſeventy-two degrees; the ſecond, by which the whole quantity of ether which is obtained is diſengaged without being accompanied by ſulphureous acid, at ſeventy-eight degrees of temperature; finally, the third, in which the ſweet oil of wine, the olefying gas, the acetous acid, the ſulphureous acid, and the carbonic acid, are produced. whilſt the mixture is elevated from eighty-eight to ninety degrees of temperature by heat communicated to it. Theſe three periods have nothing in common with each other, except a continual formation of water from the beginning to the end of the operation.

Reſting upon theſe well-confirmed obſervations, we have eſtabliſhed the theory of etherification in the following manner: In the caſe where the ether is formed by the ſimple mixture of alcohol and of ſulphuric acid, without the aid of adventitious heat, a formation which is announced by the heat as well as by the black precipitate, the carbon which is ſeparated without production of ſulphureous acid, proves that the ſulphuric acid acts upon the alcohol in a very different manner from what has hitherto been believed. In fact, this acid cannot be decompoſed at this temperature by the carbon; experience has ſhown that no action takes place in the cold between theſe two bodies. Neither is the entire alcohol decompoſed; for then ſulphureous acid would be formed, of which it is known that no trace appears at the beginning of the operation.

We muſt therefore have recourſe to an action of another order; namely, the powerful affinity which ſulphuric acid exerts upon water; it is this which determines the union of the conſtituent principles of the water exiſting in the alcohol, with which this acid is in contact; but this action is limited: there is ſoon eſtabliſhed an equilibrium of affinities, the effect of which is to maintain the new combinations in a ſtate of repoſe.

If it be proved that ether is formed by the mixture of any given quantities of ſulphuric acid and alcohol, it evidently follows that we might completely change a maſs of alcohol into ether, water, and vegetable acid, by ſufficiently elevating the ſum of the ſulphuric acid; and it is equally evident that this acid would experience no other alteration than that of being diluted with water.

It ought not to be inferred from this theory, that the ether is only the alcohol, minus the oxigen, and hidrogen; for there is ſeparated at the ſame time a quantity of carbon proportionally larger than that of the hidrogen; and it is eaſily conceived that the oxigen, which combines in this circumſtance with the hidrogen to form the water, did not ſaturate only this hidrogen in the alcohol, but that it at the ſame time ſaturated in it the carbon that is precipitated:

thus, inſtead of conſidering the ether as alcohol minus the hidrogen and oxigen, we ought, taking account of the carbon that is precipitated, and of the ſmall quantity of hidrogen contained in the water that is formed, to conſider it as alcohol, plus hidrogen and oxigen. Such is the theory of what paſſes in the ſpontaneous action between the ſulphuric acid and alcohol without the addition of extraneous heat.

When the mixture of ſulphuric acid and alcohol is ſubjected to the action of heat, the mode of the etherification is more complicated and its reſults more numerous.

Firſt, we muſt obſerve that this mixture, in equal proportions, does not enter into ebullition below the temperature of ſeventy eight degrees, whereas alcohol alone boils at ſixty-four degrees; whence it is to be concluded that the alcohol is retained by the attraction of the ſulphuric acid which fixes it. We muſt compare what then takes place in it with what happens to every other vegetable matter expoſed to the fire, the principles of which are volatilized according to the order of their affinity for caloric, carrying along with them a ſmall quantity of the more fixed elements: thus, in proportion as the ſulphuric acid attracts the alcohol and the water, the formation of which it favours, the ether which is developed attracts the caloric and is volatilized, and when the greater part of the alcohol has been changed into ether, the mixture becomes more denſe, the heat which it acquires is more conſiderable, and the affinity of the ſulphuric acid for the alcohol not yet decompoſed being augmented, the principles of this acid ſeparate; ſo that, on the one hand, its oxigen ſeizes the hidrogen of the alcohol, and forms water, which is gradually volatilized, whilſt, on the other, the ether retaining a larger quantity of carbon with which it can be volatilized at this temperature, gives riſe to the *ſweet oil of wine*, which ought to be conſidered as an ether more highly charged with carbon, which is proved by its ſuperior weight, its leſs conſiderable volatility, and its yellow colour.

With the aid of this ſimple theory, which is only the reſult of the facts, we have been led to concluſions uſeful to the chemical and pharmaceutical art, of which the following is a ſketch.

a. The formation of ether is not to be attributed, as had hitherto been thought, to the immediate action of the principles of the ſulphuric acid upon thoſe of the alcohol, but to a real re-action of the elements of the latter upon each other, and particularly of its oxigen and hidrogen, occaſioned only by the ſulphuric acid.

b. We might, ſtrictly ſpeaking, change any given quantity of alcohol into ether, without the aid of heat, by ſufficiently augmenting the proportion of ſulphuric acid.

c. The ordinary operation is divided into two principal periods with reſpect to the alteration of the alcohol; in one of which nothing elſe is formed than ether and water, in the other ſweet oil of wine, water, and acetous acid.

d. During the formation of the ether, the ſulphuric acid is not decompoſed, and the ſweet oil of wine is not formed; as ſoon as this appears, no more ether, or at leaſt but very little, is diſengaged, and at the ſame time the ſulphuric acid is decompoſed by the hidrogen alone: hence reſults the ſulphureous acid.

e. We may avoid the formation of the ſweet oil of wine by maintaining the temperature between ſeventy-five and ſeventy-eight degrees, by means of a well-conducted addition of ſome drops of water in the retort.

f. Finally, alcohol differs from ether by its containing more carbon and leſs hidrogen and oxigen; and the ſweet oil of wine ſtands nearly in the ſame relation to ether as the alcohol does to it.

76. The ether obtained by the proceſs that has been deſcribed, and which is called *ſulphuric ether*, is not very pure; it is combined with alcohol and with ſulphureous acid. In order to rectify it, it is diſtilled in a retort on the ſand-bath with fixed alkali or with magneſia. Either of theſe baſes combines with the ſulphureous acid, and the ether paſſes off very pure by the gentleſt heat. If we ſeparate the firſt half of this product, we obtain the moſt agreeable and the beſt rectified ether.

Ether is a lighter fluid than alcohol, of a ſtrong, aromatic, and very diffuſible ſmell, of a hot a hot and pungent taſte. It is ſo volatile that on pouring it out or agitating it, it is inſtantaneouſly diſſipated. It produces ſuch a degree of cold in its evaporation, that we may congeal water in a veſſel, by wrapping it round with cloths, and evaporating ether upon them. It is reduced into a ſort of ethereal gas which burns with rapidity. The air that holds ether in ſolution may paſs through water without ceaſing to be inflammable and odorous. This kind of combuſtible gas is employed for electrical experiments and for charging Volta's cannon.

Ether inflames very eaſily when it is heated in the free air, or when an inflamed body is brought into contact with it: the electric ſpark likewiſe kindles it. It emits a white and very luminous flame, and it leaves a black, ſeemingly coaly mark upon the ſurface of the bodies which we expoſe to its flame. Lavoiſier has aſcertained that acid is formed during the combuſtion of this liquor, and Scheele, that the reſidue of ether, burned upon a ſmall quantity of water, contains ſulphuric acid.

Ether diſſolves in ten parts of water, according to Citizen Lauraguais. The phenomena which ether would preſent with all the ſaline ſubſtances have not yet been examined in detail; we are only well acquainted with the action of ſome of the acids upon this inflammable liquid. Lime and the fixed alkalis do not appear to be ſuſceptible of altering it. Cauſtic ammonia mixes with it in all proportions, and forms with it a ſubſtance, the mixed odour of which might be very uſeful in faintings and ſpaſmodic affections. The ſulphuric acid becomes ſtrongly heated with ether, and it may convert a conſiderable part of it into ſweet oil of wine by diſtillation. The fuming nitrous acid excites in it a conſiderable effervescence; and the ether appears to become more conſiſtent, more coloured, and more oily in this experiment.

Mixed with the muriatic ſolution of gold, it retains a part of this metal for ſome time, and ſeems then to act like the volatile oils, which likewiſe retain a portion of oxide of gold; but at the end of ſome days the gold ſeparates in the brilliant, metallic, ductile, and cryſtalline form.

Ether diſſolves the volatile oils and the reſins like alcohol; and phyſicians frequently employ etherated tinctures. It diſſolves the ſoftened caoutchouc well, if previouſly ſwelled in boiling water, and cut into ſmall fragments. This ſolution, as it evaporates, leaves a layer of pure and elaſtic caoutchouc upon the bodies on which it has been ſpread.

77. The nitric acid, and eſpecially the nitrous acid, act in a much more rapid manner than the ſulphuric upon rectified alcohol: here, inſtead of promoting the re-action by heat, every attempt is made to moderate it, either by diluting the two liquids, or by cooling their mixture.

Navier, a phyſician at Chalons, is the firſt who has given an eaſy and moderately expenſive proceſs for preparing the nitrous ether. According to this chemiſt, we take a very ſtrong *Sèvres* or ſtone-bottle, pour into it twelve parts of pure and well-rectified alcohol, and immerſe it in cold water, or, which is ſtill better, into ice; then add at different times, ſhaking the mixture each time, eight parts of concentrated nitric acid, but in part nitrous; the bottle is to be well cloſed with a good cork, tied over with leather; this mixture is left to ſtand in a remote place, in order to prevent the accidents which ſometimes ariſe from the breaking of the bottles. After ſome hours, bubbles riſe from the bottom of the veſſel, and drops collect at the ſurface of the liquor which gradually form a ſtratum of real ether. This diſengagement takes place during four or ſix days. When no motion is any longer obſerved in the liquid, the ſtopper is perforated with a bodkin, in order to let a certain quantity of nitrous gas eſcape, which, without this precaution, would iſſue out with rapidity in uncorking the bottle, and carry with it the ether which would be loſt. When the gas is diſſipated, the bottle is gently uncorked; the liquor which it contains is poured into a funnel; the reſiduum is ſeparated, by preſſure of the finger, from the ether which ſwims above it, and the latter is received into a ſeparate bottle.

78. Mr. Woulfe, an Engliſh chemiſt, has given another proceſs for preparing the nitric ether.

It conſiſts in employing very large veſſels, in order to preſent a large ſpace to the elaſtic fluids which are diſengaged. We take a matraſs of white glaſs, from eight to ten litres, terminated by a neck about two metres and a half in length; this is placed upon a three-legged ſupport, ſufficiently high for a chafing-diſh to be placed beneath it; to the neck of this matraſs a tubulated capital is fitted, to the beak of which a tube of glaſs is adapted, of equal length with the neck of the matraſs: this laſt is received by its lower extremity into an adopter with two necks, perforated below with a tubulure to which a bottle is fixed; to the third neck of this veſſel are added the bottles which conſtitute Woulfe's apparatus that has been already ſeveral times deſcribed. When all theſe veſſels are well luted, equal parts of rectified alcohol and of fuming nitrous acid are poured into the matraſs by the tubulure of the capital; the capital is then cloſed with a glaſs ſtopper which is ſecured with a leather bound round with packthread. As ſoon as the mixture is made it becomes much heated; vapours are diſengaged from it, which rapidly paſs through the neck of the matraſs; and the latter being heated till the liquor which it contains boils, with the aid of the chafing-diſh placed under it, nitric ether paſſes into the matraſs which ſerves as the receiver. This proceſs, though very ingenious, has ſeveral inconveniences; it requires a conſiderable time to fix the apparatus, which is very dear and very embarraſſing; beſides which, it is attended with danger, for, notwithſtanding the ſpace given to the vapours, they are diſengaged with ſuch rapidity, that the apparatus frequently breaks with a loud exploſion. In five operations of this nature which I have witneſſed or aſſiſted in, from 1772 to 1778, I have twice ſeen the veſſels fly in pieces with a violent exploſion.

79. Mr. Bogues publiſhed, in 1773, another method of preparing the nitric ether. He adviſes to mix in a glaſs retort, of a capacity to contain 8 kilogrammes (about 20lbs.) of water, half a kilogramme of alcohol, with the ſame quantity of nitric acid, diluted ſo as to give only 24 degrees by the areometer for the acids; to adapt to the retort a matraſs capable of containing twelve kilogrammes of water; to afford a paſſage to the gas by adjuſting two quills to the junction of the lutes, and to diſtil with a very gentle fire, immerſing only a very ſmall part of the retort in the ſand. By this method he has obtained a little more than a third of the weight of the alcohol of ſufficiently pure nitric ether. It appears from what Rozier ſays in his Journal de Phyſique, that Mitouard employed, ſince 1770, a proceſs much reſembling that of Mr. Bogues. This chemiſt put four parts of fuming ſpirit of nitre with twelve parts of alcohol to diſtil in a retort, which he ſuffered to reſt but very lightly upon the ſand, and by this means, which appears to be the moſt ſimple of all, he obtained nitric ether ſimilar to that of Navier.

80. Finally

80. Finally Citizen Laplanche, apothecary at Paris, has ſucceſſively contrived two methods for preparing the nitric ether by ſufficiently convenient proceſſes. The firſt conſiſts in putting nitre into a tubulated retort of ſtone-ware, to which is adapted either one large matraſs or two connected together, and pouring through the tubulure firſt concentrated ſulphuric acid and afterwards alcohol. The ſulphuric acid diſengages the nitric, which re-acts upon the alcohol, and forms almoſt immediately nitric ether. As it might be ſuſpected that the ether prepared by this proceſs was in part ſulphuric, he has ſubſtituted in ſtead of this firſt method a ſecond very ingenious proceſs. He adapts to a tubulated glaſs retort, into which he has put well dried nitre, an adopter and a matraſs which communicates by a curved tube with an empty bottle; the latter communicates by the aid of a ſyphon, into another bottle which contains alcohol of the moſt perfect kind to the amount of half the weight of the nitre. The whole being well luted, and the retort placed upon a bath of aſhes, concentrated ſulphuric acid, alſo to the amount of half the weight of the nitre, is poured upon the nitre through the tubulure of this laſt veſſel; the retort is cloſed with a glaſs ſtopper; the fire is applied till ebullition is produced, and in this ſtate it is kept till no more vapours paſs over. In this experiment, the ſulphuric acid diſengages that of the nitre, part of which paſſes into the matraſs and part into the ſecond flaſk.

When the operation is completed, the matraſs contains fuming nitrous acid, the retort ſulphate of pot-aſh, and the ſecond flaſk a liquor, etherated by the action of the vapour of the nitric acid upon the alcohol. This laſt liquor is diſtilled in a retort with a ſimple receiver, and only two thirds of the product are taken. This product is again diſtilled with a fifth of fuming nitrous acid which is gradually poured upon it by means of a glaſs funnel with a long pipe; only two thirds of it are taken; finally, this ſecond product is rectified upon pot-aſh, dividing the product of the ethereal liquor into two parts; the firſt is very pure nitric ether, the ſecond forms a kind of anodyne nitrous mineral liquor. The reſidues of the two rectifications form what was formerly called *dulcified ſpirit of nitre.*

81. The nitric ether obtained by all theſe different proceſſes is a yellowiſh fluid, equally volatile, and equally evaporable with the ſulphuric ether; its ſmell is ſimilar to that of the latter, though ſtronger and leſs agreeable; its taſte is hot and more diſagreeable than that of the ſulphuric ether; it is frequently of a yellow colour; it cauſes the ſtoppers of the bottles in which it is incloſed to fly out, becauſe a large quantity of gas is continually diſengaged from it; it conſtantly gives a red and yellow tinge to the linen of the corks with which it is compreſſed; it diffuſes whilſt burning a more brilliant flame and a thicker ſmoke than the ſulphuric ether;

it alſo leaves a coal ſomewhat more abundant; like the ſulphuric ether, it ſeparates gold from its ſolution and becomes charged with a certain quantity of it. When it is kept for a long time in a cloſe veſſel, water containing a ſmall quantity of oxalic acid is formed at the bottom of this ether: it is rendered colourleſs by diſtilling it from the alkalis; ſugar has ſucceeded with Citizen Deyeux in effecting this purification, and this body retained a burning acrid oil which he believes to be analogous to the ſweet oil of wine, and formed during the diſtillation of the ether; he adds that it is produced more ſpeedily by the action of the nitric acid than by that of the ſulphuric, and that it is diſengaged at the ſame time with the ether, which is the cauſe of its colour: he has alſo found that by mixing ſixteen parts of water with one part of nitric ether, in a bottle provided with a tube, the nitric gas which it contains is ſeparated from it by a ſpontaneous efferveſcence, and that, when once deprived of this gas, the nitric ether may be kept like the ſulphuric, without breaking the veſſels in which it is incloſed. It is in this manner that he preſcribes it to be rectified by means of ſugar, and deprived of gas by means of water, for medicinal uſe.

82. The reſiduum of nitric ether is of a yellow colour; its ſmell is acid and aromatic; its taſte pungent and reſembling that of diſtilled vinegar. When diſtilled it affords, according to Citizen Baumé, a clear liquor, of a more plea-

ſant ſmell than the nitric ether, of an agreeable acid taſte, which reddens the ſyrup of violets, unites with water in all proportions, and effervesces with the carbonate of pot-aſh: this is acetous acid mixed with a little ether. There afterwards remains in the retort a matter of an amber-yellow colour, friable, reſembling amber, attracting the humidity of the atmoſphere, and acquiring a pitchy conſiſtence, and diſſolving in water without rendering it mucilaginous. This ſubſtance, which Citizen Baumé calls *ſaponaceous gum*, affords by the retort ſome drops of an acidulous liquor, which is very clear, of an oily conſiſtence and a ſlight empyreumatic ſmell. After the diſtillation a coal remains which is ſpongy, brilliant, without taſte, and very fixed in the fire. Bucquet ſays that if we evaporate the liquor which remains after the formation of the nitric ether, it aſſumes the conſiſtence of a mucilage, and that there are formed in it after a longer or ſhorter ſpace of time, ſaline cryſtals, much reſembling hairy caterpillars, which have been called *Hiærne's cryſtals*, after the name of the chemiſt who firſt deſcribed them; it is now known, according to the experiments of Mr. Hermſtaedt, that they are oxalic acid. It is evident, according to all theſe details, to which we may add that carbonic acid gas paſſes over during the whole of the action of the nitric acid upon the alcohol, that this action does not differ from that of the ſulphuric acid, except in the circumſtance that the carbon which is precipitated by the latter is diſſolved and burned in the oxigen of the former; that oil is formed more quickly and more abundantly; that the etherification proceeds from the ſame cauſe, and that oxalic and acetous acids are formed at the ſame time with the ether, the oil, the water and the carbonic acid. The rapidity of this decompoſition, and the gaſes which are diſengaged whilſt it takes place, render the etherification by the nitric acid much more tumultuous than that by the ſulphuric, and this is the cauſe why it is ſo frequently accompanied with exploſion, and the burſting of the apparatus, when it is made with a too highly concentrated acid.

83. The muriatic acid has no ſenſible action upon alcohol; this acid is dulcified, either by the ſimple admixture of that liquid, or by diſtillation with it, as the two others are when mixed in ſmall quantity with alcohol. Citizen Baumé, in his diſſertation upon ether, ſays he has obtained a ſmall quantity of muriatic ether by cauſing the muriatic acid and alcohol to meet in vapour. Ludolf and Pott have employed the ſuper-oxigenated and ſublimed muriate of antimony, or the *butter of antimony*, with this view. Mr. de Bormes has preſcribed to diſſolve oxide of zinc in muriatic acid, and to diſtil this ſalt concentrated by evaporation in cloſe veſſels with alcohol. This proceſs affords muriatic ether with ſufficient facility.

But no one, previous to the chemical revolution, had followed up this work with ſo much attention as Courtanvaux, of the Academy of Sciences; he ſucceeded in preparing the muriatic ether by the following proceſs: One part of alcohol, with nearly three parts of ſuper-oxigegenated muriate of tin, or the fuming liquor of Libavius, are poured into a glaſs retort; a very violent heat is excited, and a white ſuffocating liquor riſes, which diſappears as ſoon as the liquor is agitated; an agreeable ſmell is then diſengaged, and the liquor aſſumes a yellow colour. The retort is placed upon a bath of hot ſand; two matraſſes are luted to it, the laſt of which is immerſed in cold water. Firſt dephlegmated alcohol paſſes over, and the ether riſes ſoon after: this is perceived by its agreeable ſmell, and by the ſtreaks which it forms upon the roof of the retort. As ſoon as this ſmell changes, and becomes ſtrong and ſuffocating, the receiver is changed, and the diſtillation is continued; a clear acid liquor is obtained, with ſome drops of *ſweet* oil ſwimming upon it, which is ſucceeded by a yellow matter of a butyraceous conſiſtence, a real muriate of tin, and at laſt a brown, heavy liquor, which exhales white vapours in great abundance: there remains in the retort a grey pulverulent matter, which is an oxide of tin. The ethereal product is poured into a retort upon carbonate of pot-aſh; a lively efferveſcence takes place, and a very abundant precipitate is formed, which proceeds from the oxide of tin which the acid had carried away with it during the diſtillation: a ſmall quantity of water is added, and diſtillation is performed with a gentle heat; about the half of this ethereal product is obtained. All the liquors which paſs after the muriatic ether are highly charged with oxide of tin; they attract the moiſture of the air, they unite with water without forming any precipitate. It was not known to what we ought to attribute the very rapid action of the muriate acid contained in the *fuming liquor* of Libavius upon the alcohol, whilſt the pure acid exerted no action at all upon it; but it is evident that this action is owing to the circumſtance that this acid is in the ſtate of oxigenated muriatic acid in this metallic muriate, and that it is to the exceſs of the oxigen that we ought to attribute the property which it poſſeſſes of converting the alcohol into ether. Such is the theory which was firſt advanced by me in 1781, and which has been confirmed by the labours of Citizens Berthollet and Pelletier, as I ſhall proceed to ſhow.

84. Citizen Laplanche has propoſed, for preparing the muriatic ether, to pour into a tubulated retort ſulphuric acid and alcohol upon decrepitated muriate of ſoda. The muriatic acid gas, diſengaged by the ſulphuric acid, meets in the receiver with the alcohol in vapour, and combines with it. He aſſures us that there reſults an etherated acid, which is rectified upon pot-aſh,

pot-aſh, in order to obtain the pure ether from it; but it is probable that if a little ether is formed in this proceſs, it proceeds only from a ſmall portion of oxigenated muriatic acid formed in the operation. Pelletier has ſucceeded in producing muriatic ether by diſtilling in a large tubulated retort oxide of manganeſe, muriate of ſoda, concentrated ſulphuric acid, and rectified alcohol. The ether, which is obtained by this proceſs, forms half the weight of the alcohol that has been employed. Citizen Berthollet has diſcovered that the ſame ethereal liquor is obtained by diſtilling with a mild heat alcohol ſaturated with oxigenated muriatic acid gas; and it has ſince been obtained by diſtilling upon the oxide of manganeſe a mixture of highly rectified alcohol and well concentrated muriatic acid. Every thing proves therefore, that the etherification proceeds from the oxigen added to the muriatic acid.

The muriatic ether is very tranſparent and very volatile; it has nearly the ſame colour as the ſulphuric; it burns like it, and emits ſimilar fumes, but it differs from it by two properties; the one that it exhales, in burning, a pungent ſmell as ſtrong as the ſulphureous acid; the other, that it has a ſtyptic taſte ſimilar to that of alum. Theſe two phenomena are undoubtedly owing to ſome foreign bodies which it contains; for every thing indicates that ether is in itſelf an identic ſubſtance, a conſtant product of the decompoſition of the alcohol, by whatever acid and even by whatever re-agent it has been formed; for we ſhall ſoon ſee that the action of an acid is not indiſpenſably neceſſary to its production.

85. It has been often tried to produce ethers with the phoſphoric, the tartarous, &c. acids; but all theſe attempts have been fruitleſs, becauſe theſe acids have too little attraction for water to favour its production by the decompoſition of the alcohol, as the ſulphuric acid does, or have too ſtrong an adheſion with oxigen to ſuffer this principle to ſeize upon thoſe of the alcohol, or are too eaſily decompoſed themſelves by the temperature at which the ethers are generally prepared, to be able to re-act upon the alcohol, and effect its etherification. Beſides which, when chemiſts endeavoured with a ſort of obſtinacy to form ethers with every acid, either new, or that had not yet been examined as to its action upon alcohol, it was the general opinion that each ether was different from all the reſt; but it is now known, that excepting the admixture of a ſmall quantity of the acid employed, ether is the ſame body by whatever acid it may have been formed.

86. Alcohol is decompoſed by thoſe metallic oxides which moſt eaſily relinquiſh their oxigen, and it even ſometimes paſſes by the action of heat into the ſtate of vapour in this decompoſition, as Citizen Van-mons has diſcovered. We here ſee the ſame fact, and conſequently the ſame theory as in the action of the nitric and of the oxigenated mu-

riatic acid upon alcohol. We obtain the ſame reſult, and even a much more ſtriking effect, by the double decompoſing attraction which the metallic ſolutions exert upon alcohol, when it is diſtilled with theſe bodies. By diſtilling theſe mixtures, we obtain proportions of ether ſo much the larger as the ſolutions are more concentrated, and as the metallic oxides which they contain more eaſily relinquiſh their oxigen. It is eſpecially with the nitrates of mercury, of ſilver, of lead, and with the ſuper-oxigenated metallic muriate, that theſe effects are the moſt energetic.

87. Finally, the decompoſition of alcohol by its inflammation is modified in a more or leſs remarkable manner in the colours of the flame which it affords; by a great number of bodies which it holds in ſolution, or which are mixed with it, and though the real cauſe of theſe modifications are not yet known, they are in themſelves ſufficiently ſtriking and ſingular to deſerve at leaſt to be carefully deſcribed. Thus the boracic acid gives to the colour of the flame of alcohol a remarkable yellowiſh-green caſt; the ſoluble ſalts of ſtrontian, a purple colour; thoſe of barites, a pretty deep yellow; thoſe of iron, light reds; and thoſe of copper, blueiſh greens, very different from the tinge produced by the boracic acid.

E. *Species.*

88. Though chemiſts have for ſome time believed that the alcohol extracted from different fermented liquors was different; though they have eſpecially diſtinguiſhed the brandies of wine, that of beer, called *malt ſpirits*, the alcohol of cherries, deſignated by the name of *Kirchenwaſſer;* the brandy of cider; *rum*, or the brandy of the ſugar-cane; *arrack*, or the brandy of rice; yet it is well known at preſent that all theſe products are one and the ſame, poſſeſſing identical properties, and preſenting exactly the ſame chemical phenomena.

89. However, for domeſtic purpoſes, for the uſes of the arts, and eſpecially for the delicacy of our organs, it is indiſpenſably neceſſary to admit the diſtinction of the ſpecies of which I have juſt ſpoken, ſince their different taſte, their very diverſified inflammability, lightneſs, and ſolvent properties, render each of them uſeful in different circumſtances. But theſe modifications depend much more upon the manner in which they have been prepared, and upon the few precautions that have been taken in their diſtillation, than upon their peculiar nature. In order to convince ourſelves of this, it is ſufficient to obſerve, that the brandy extracted from wines is not the ſame in its taſte, its ſmell and its ſtrength, in the different countries where

it is prepared, though the primitive liquor which furniſhes it be identical, becauſe its diſtillation is conducted in a different manner. Still more muſt this happen with fermented liquors, charged with much extractive and mucilaginous matter, ſuch as the beers and the ciders, which, when they are ſtrongly heated, as is done in moſt diſtilleries, become thick, burn or char at the bottom of the alembics, and thus afford acrid, odorous, empyreumatic brandies, as they carry along with them a portion of oil in the diſtillation. It is known with what energy alcohol retains the ſmall quantity of oil capable of giving it ſtrong ſmells, and a taſte foreign to its own. It is known that when once ſaturated in this manner by diſtillation it is impoſſible to deprive it of them, and this ſufficiently explains all the various properties, ſo ſenſible to our organs, and nevertheleſs ſo inconſiderable in our chemical operations; which we meet with in the different kinds of brandies and of alcohol of commerce.

F. *Uſes.*

90. THE uſes of alcohol are extremely numerous. Its property of ſupporting and raiſing the diminiſhed ſtrength of the body, of augmenting the energy of the contractile fibres, the motion of the circulation, and the activity of the whole animal ſyſtem, gives it a place amongſt the moſt important remedies. It is rarely adminiſtered

alone, at leaſt not unleſs reduced to vapour, in order to introduce it with the air into the lungs, and cauſe it to act upon the relaxed fibres or the ulcers with which they may be afflicted. It is combined with a multitude of different ſubſtances, in order to add to its virtues and to adapt it to the indications which we wiſh to fulfil. It is rendered very ſolvent by pot-aſh in the acrid tincture of tartar and the *lilium*, very antiſeptic with camphor, antiſpaſmodic with the ſmall portion of volatile oil which gives it ſmell and modifies it, in what are improperly termed *diſtilled ſpirituous waters*, very aſtringent with the addition of a quarter of its weight of ſulphuric acid, which conſtitutes the water of Rabel. It is very ſtomachic and cordial when combined with reſins and oxigenated extractives, as it is in the artificial balſams, the tinctures and the elixirs, or the *ſpirituous* compounds, of which ſuch a number of varieties are enumerated in the books of medical receipts and formulæ.

91. Alcohol reduced to the ſtate of ether is one of the moſt powerful ſtomachic, tonic and antiſpaſmodic remedies, as it acts by being ſuddenly reduced into vapour in the ſtomach, where it is received upon a large ſurface at once, and upon almoſt the whole of the nervous ſyſtem. It has been eſpecially recommended as a ſolvent of biliary calculi ; but it is evident that it acts in this caſe much more by its ſedative property than by a real ſolvent quality, ſince the ſlighteſt knowledge of anatomy is ſufficient

to ſhow that it cannot penetrate in ſufficient abundance into the *ductus choledochus* and *cyſticus* to act immediately upon the concretions contained in the gall-bladder. Ether intoxicates more powerfully and in a much ſmaller doſe than alcohol. By mixing it with the firſt aromatic alcohol which paſſes in the diſtillation with ſulphuric acid, and with ſome drops of volatile oil which paſſes after it, the *anodyne mineral liquor of Hoffman* is prepared, which is much inferior to the ether itſelf, and acts much more feebly and unequally. What is called in pharmacy *nitrous anodyne mineral liquor* is the product which ſucceeds the *nitrous* ether in the diſtillation. As to the muriatic ether, it is a very bad medicine, as it is never uniform, frequently contains acid, and is much leſs etherated than the two preceding. The common or ſulphuric ether, well rectified, is preferable to all others.

92. It is on account of its tonic and corroborant virtues, that alcohol is ſo frequently employed in the preparation of very agreeable liquors which are taken after meals to promote digeſtion. The name of *ratifias* is given to the infuſions of a number of ſubſtances in brandy, ſweetened with ſugar, and more particularly that of *liqueurs*, to the combinations of well rectified alcohol with volatile oils and ſyrups, in different proportions. The ſyrup furniſhes the water and the ſugar which ſoften the burning acrimony of the alcohol; the volatile oil ſupplies

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the perfume; and when theſe ſubſtances are combined in proper proportions, ſo that no flavour is too predominant; when the combination is very intimate, which it eſpecially becomes in the courſe of time, they produce extremely agreeable beverages. They are varied without limit, according to the volatile oil that is uſed; thoſe of vanilla, of the roſe, the orange, the citron, the clove, the nutmeg, cinnamon, aniſeed, are preferred to moſt others, on account of the ſtrength or pleaſantneſs of their fragrance. They are frequently combined with each other, and ſometimes even in large quantities, and in this caſe care is taken to compound them in ſuch a manner that none may predominate over the reſt. In general they are prepared with one part of rectified alcohol, two parts of water, one of refined ſugar, and ſome drops of volatile oil. Sometimes the alcohol is made to act immediately upon the intire vegetable matters, in order to give it more of what is called the flavour of the fruit. They are coloured with cochineal and ſaffron. Theſe very pleaſant liquors are uſeful only when taken moderately and in ſmall quantities; their abuſe is pernicious and dangerous: inſtead of ſtrengthening they then weaken the powers of the body and eſpecially thoſe of the ſtomach.

93. Alcohol, by the property which it poſſeſſes of eaſily diſſolving the volatile oils, of carrying them off by diſtillation, ſo as to form highly odorous and aromatic liquors, is very much em-

ployed in the perfumer's art. It is with this ſubſtance that they prepare the pleaſant liquids known by the name of ſcented waters, the *eau de bouquet*, the *eau de milleſleurs*, the *pots pourris*, &c.: they alſo combine ſeveral of them together. Benzoin, ſtorax, ambergris, muſk, vanilla, are frequently employed in theſe compoſitions uſed for the toilet. Theſe are alſo products of art which ought never to be employed but with reſerve and moderation, as it becomes neceſſary to augment the doſe when once habituated to the abuſe of them; and by the continual effect of perfumes the organs become weakened and ſuffer a remarkable relaxation.

94. Alcohol is employed as a combuſtible to ſupply table-lamps, to afford brilliant flames in public ſpectacles, and for performing a great number of philoſophical and chemical experiments. It is particularly employed as a ſolvent in the preparation of the fineſt and the moſt coſtly drying varniſhes. Theſe varniſhes are in general ſaturated ſolutions of tranſparent reſins that are dry, little coloured, or even intirely tranſparent, ſuch are copal, ſandarach, maſtich, olibanum. Alcohol is too coſtly to ſerve for dyeing in the large way; but it is ſometimes employed for dyeing ſilks and ribbands.

95. It is one of the moſt uſeful ſolvents to chemiſts. It is eſpecially applied to the ſeparation of the deliqueſcent ſalts in the analyſis of the reſiduums of mineral waters, of the aſhes of

plants, &c. to the extraction and purification of pot-aſh, ſoda, &c.; to the examination of the vegetable matters, after having treated and exhauſted them with cold and hot water; to the treatment of ſome animal ſubſtances; to the precipitation of ſalts that are inſoluble in alcohol though ſoluble in water, &c. &c.

SECTION VI.

Of the Cauſes or the Mechaniſm of the Vinous Fermentation, and of the Formation of Alcohol.

96. THOUGH I have ſhown in the two preceding paragraphs that the alcohol did not exiſt ready formed, or intirely compoſed in the wine; though I have conſidered it as a remote product of the vinous fermentation, it is however no leſs true that it proceeds from this fermentation; that without it it would not exiſt, and that it is really formed by this proceſs, ſince a fermented vinous liquor is requiſite for obtaining it. It is no leſs evident that it proceeds from the ſugar, becauſe it is indiſputably neceſſary that a liquor ſhould be ſaccharine in order to become vinous, and ſince, when this liquor has paſſed into the ſtate of wine, it no longer contains any ſaccharine ſubſtance.

97. Chemiſts have long known that alcohol is formed at the expenſe of the ſaccharine matter: it is only ſince the pneumatic doctrine, and by the fine experiments that have ſerved to eſtabliſh it, that the hope of determining the mechaniſm by which this kind of change is effected, has been conceived and already in part realized. Lavoiſier is the firſt and almoſt the only chemiſt who has occupied himſelf with it; and though ſomething is ſtill wanting, on the ſcore of preciſion, to the ingenious reſults which he has given us reſpecting this transformation, yet theſe reſults are ſufficiently fair and concluſive, eſpecially when compared with the improbable hypotheſes which had been given before him, to authorize our conſidering this part of the ſcience as greatly advanced, and very well calculated to diffuſe great light over the vegetable analyſis.

98. This illuſtrious chemiſt begins by ſhowing, that in the vinous fermentation, as in every chemical operation, a real equation takes place between the principles of the body which ferments, and thoſe which it affords after having fermented: that the juice of the grape, and more particularly the ſugar, affording by fermentation, on the one hand carbonic acid, and on the other alcohol, we muſt thence conclude the ſugar to be = carbonic acid + alcohol; and that by knowing well the nature of each of theſe bodies and that of the ſugar, we may exactly appreciate what happens during this fermenta-

tion, or in what the change of nature, which it effects may conſiſt. According to this view, knowing the nature of the ſugar in which he had found 0,64 of oxigen, 0,28 of carbon, and 0,08 of hidrogen, he fermented it with a ſmall quantity of yeaſt which he had alſo examined: his experiment was made in an ingenious apparatus, in which he collected exactly the carbonic acid diſengaged, and loſt none of the products of the fermentation. Without entering here into the detail of the proportion of theſe products, with reſpect to which ſomething is wanting in accuracy, as muſt have been the caſe in a firſt experiment, I ſhall here exhibit only the general reſults, which alone are of intereſt to the general progreſs of the theory, and conduct us to the knowledge of the mechaniſm of fermentation.

99. In calculating the proportion of the primitive principles contained in the 0,96 of ſugar totally decompoſed in his experiment, Lavoiſier found that this quantity of oxigen, of carbon, and of hidrogen was ſufficient for forming all the alcohol, all the carbonic acid, and even the portion of acetous acid which he obtained. Hence he concluded that it is not neceſſary to ſuppoſe any decompoſition of the water, as he had done at firſt, for explaining the compoſition of theſe two principal products, the alcohol and the carbonic acid; but that the mechaniſm of the vinous fermentation conſiſts only in a change of equilibrium effected in the conſtituent principles

of the ſugar, and in a new union under another order of theſe principles; a change favoured only by the preſence of the water and of the caloric, and commenced more eſpecially by the ferment of the yeaſt which he had employed.

100. The effects of this fermentation are reduced in this theory founded upon experiment, to the ſeparation of the ſaccharine matter into two new compounds; to the oxigenation of the one at the expenſe of the other, to form carbonic acid, a neceſſary product of the vinous fermentation; and to the diſoxigenation of the other in favour of the firſt, in order to compoſe with it the inflammable ſubſtance called alcohol; ſo that, ſays he, if it were poſſible to re-combine theſe two products, the alcohol and the carbonic acid, in the ſame proportions in which they reſpectively formed the ſugar that has fermented, the ſugar would be reproduced ſuch as it was previous to the fermentation. According to him, the hidrogen and the carbon do not exiſt in the oily ſtate in the alcohol, but they are united with a proportion of oxigen, which, being maintained with them at a certain equilibrium of compoſition, conſtitutes a new ſpecies of oxide ſtill very inflammable, and which, when decompoſed by paſſing it, as I have already indicated, through a red-hot porcelain tube, again forms water and carbonic acid, and depoſits a portion of carbon.

101. Thus the alcohol, which is ſugar—a notable quantity of carbon and of oxigen + an equally notable quantity of hidrogen, to the

exact knowledge of which nothing more is wanting than that of its primitive principles;—this alcohol, which is ſugar, de-carbonated and diſoxigenated or hidrogenated ſugar, comports itſelf exactly as ſuch in all the experiments to which it is ſubjected. It is much more light and volatile than ſugar on account of its proportion of hidrogen; it burns without fumes and without ſoot; it affords a large quantity of water in its combuſtion. It is alſo evident, that when we conſider the mechaniſm of the vinous fermentation in the comparative properties of its products, we may regard it as two operations performed at the ſame time, as a ſlow and ſucceſſive combuſtion of the carbon, and a decombuſtion of the other part of the ſugar, which then becomes more combuſtible, and forms the alcohol.

102. Accordingly, Lavoiſier has terminated theſe fine inquiries upon fermentation, by remarking that this operation preſents a new means of analyzing ſugar; that ſuppoſing a vegetable matter ſubjected to fermentation to be well known, we may conſider it with reſpect to the products which it affords, as a real algebraic equation, and that each of the products that compoſe it may give a real value, which enables us to rectify the experiment by the calculation, and the calculation by the experiment. It is thus, as an important means of analyſis, that I have repreſented the ſtudy of the vegetable fermentations; and it muſt here

appear, that in order to become perfectly acquainted with the vinous fermentation and its products, to arrive by this knowledge at that of its real mechaniſm, nothing more is neceſſary than to find the exact relation of the proportions between the principles which combine with each other; and this is what may be hoped from further chemical reſearches, purſued with the ſame ſpirit, and with the ſame apparatuſes which Lavoiſier has already ſo uſefully employed.

The general reſult of what is already known concerning the vinous fermentation is, that the original intention of nature in giving riſe to it, has been to reduce the vegetable compound to a more ſimple order of compoſition, ſince one of the products of this movement is already a binary compound, namely, the carbonic acid. We ſhall acquire a ſeries of irrefragable proofs of this leading truth in the examination of the other ſucceſſive fermentations on which I ſhall treat in the ſubſequent articles.

ARTICLE V.

Of the acid Fermentation and of its Products, or of the acetous Acid.

1. THE acid fermentation was conſidered as the ſecond degree of general fermentation by Boerhaave, ſince it is in fact by an inteſtine

movement of which wine is ſuſceptible, that the acetous acid is fabricated; but ſeveral vegetable ſubſtances that are not vinous may form this acid, and it is not an indiſpenſable condition of its exiſtence that it ſhall have been preceded by the vinous fermentation. In order to place whatever belongs to the hiſtory of this fermentation in a more perſpicuous light, I ſhall divide this article into ſix paragraphs. The firſt ſhall treat of the conditions and the phephenomena of the acetous fermentation; the ſecond, of ſeveral other means of obtaining acetous acid, different from that of fermentation, or of what I call in general *acetification*; the third, of the phyſical properties of vinegar, and of the acetous acid; the fourth, of its chemical properties; the fifth, of the different ſpecies or modifications of the acetous acid, and eſpecially of that which is called *acetic acid;* laſtly, the ſixth and concluding paragraph ſhall deſcribe the uſes for which vinegar, the acetous acid, and the acetic acid are employed.

SECTION I.

Of the Conditions, and of the Phenomena of the Vinous Fermentation.

2. THOUGH many vegetable ſubſtances, eſpecially the leaves immerſed in water, farinas diluted with it, and the mucilages prepared from

them with hot water, are capable of experiencing a ſpontaneous inteſtine motion which converts them into acid, it is more particularly upon wine that this kind of fermentation is practiſed, and has been well obſerved. There are three conditions eſſential to a vinous liquor, in order that it may paſs into the acetous fermentation. In the firſt place, it muſt be expoſed to a temperature from twenty to twenty-five degrees of Reaumur's thermometer. It is known that wines depoſited in vaults, the temperature of which is pretty conſtantly at ten degrees, remain without alteration. Secondly, it is neceſſary that they ſhould contain a certain quantity of mucilage and of tartar. On this account the wines ought not to be fined with iſinglaſs till the moment of bottling them. They are made to ferment much more quickly, eſpecially thoſe which are very generous, and yield much alcohol in diſtillation, by adding any kind of mucilage to them; ſugar even in ſmall proportion, but eſpecially melaſſes, ſerve alſo as a ferment. Thirdly, it is neceſſary that the wines ſhould enjoy the contact of the air; the more this contact is multiplied, the more quickly does the acetous fermentation eſtabliſh itſelf; a ſmall quantity of wine remaining at the bottom of a bottle paſſes quickly into the ſtate of vinegar, on account of the large volume of air which touches it in every part; and Rozier has found that a bladder filled with air attached to the bung-hole of a caſk of wine that was turning ſour, was emptied by the abſorption of the air which it contained.

3. All wines are ſuſceptible of undergoing the acetous fermentation; but though thoſe of inferior quality are more particularly allotted to this purpoſe, the experiments of Becher, ſince repeated by Cartheuſer, prove that the ſtrong wines, which yield much alcohol by diſtillation, afford the beſt vinegar. Thus the wines of the country about Orleans, that are of good quality and ſufficiently generous, afford a vinegar which is in high eſtimation; in this manner alſo the quality of the vinegar prepared with weak wines is improved, by adding a little brandy to them previous to their fermentation. For the reſt, though the chemiſts have long conſidered vinegar on this account as a *ſpirituous acid*, we ſhall ſee hereafter that this property is relative only to the ſmell and taſte of the vinegar employed in the ordinary uſes of life, but by no means to its proper acid nature, which is independent of the preſence, or the direct proportion of the alcohol that may be united with it.

4. Whilſt the wine undergoes the acetous fermentation, a very ſenſible ebullition and hiſſing are perceived in the liquor; it becomes heated and turbid; it preſents many filaments and bubbles, which traverſe it in all directions; it exhales a lively acid ſmell, without diſengaging carbonic acid, as is the caſe in the vinous fermentation. Gradually theſe phenomena abate,

the heat diminiſhes, the commotion ſubſides, the liquor becomes clear, after having depoſited a ſediment in reddiſh glutinous flakes, which attach themſelves to the ſides of the veſſels. The wine is afterwards diſpoſed to undergo, provided all the circumſtances favour it, a new and laſt fermentation which would change its nature, and intirely decompoſe it; and it ought not to be forgotten that ſuch a diſpoſition actually exiſts, and that precautions muſt be taken againſt the proceſs of decompoſition if we wiſh to preſerve it.

5. According to the conditions and the phenomena that have been indicated, it is not difficult to convert wine into vinegar; time alone effects this change in ill-cloſed veſſels that are expoſed in places ſufficiently warm. Thus, in many families, a barrel filled with wine already tending to aceſcence is placed in a lower room kept conſtantly at the temperature favourable to acetification. When it has intirely turned ſour, in fifteen or twenty days, a ſmall quantity is drawn off for domeſtic purpoſes, by means of a cock placed towards the bottom, and the barrel is ſimply filled up with an equal quantity of wine; by this means the wine that has been added paſſes ſpeedily into the ſtate of vinegar, ſo that this barrel, when once prepared as I have ſaid, ſuffices for the ſupply of the whole eſtabliſhment without a new fabrication being required, ſince it is only neceſſary to replace the vinegar that has been drawn

off with an equal quantity of wine. We ſee here that the vinegar already formed ſerves as a ferment to the wine which is added. When it is neceſſary from any circumſtance to recommence the operation, and when it is required again to make a barrel of vinegar for the firſt time, we throw into the wine that is put into the barrel that ſkin, or kind of membrane, which is taken out of barrels that have contained vinegar for a long time, and which is called *mother of vinegar*. This is a mucous, concrete depoſition, proceeding from the gradual decompoſition of the vinegar, and ſerves as a ferment to give riſe to the acid fermentation in the other wine. This fact is ſo well known, that in neighbouring families this *mother of vinegar* is borrowed in the ſame manner as the leaven of bread.

6. Boerhaave has given, in his Elements of Chemiſtry, a very good proceſs for making vinegar, which is ſtill practiſed in many places. Two veſſels are taken, in which is fixed at ſome diſtance from their bottom, an hurdle of oſier, upon which vine branches and ſtalks are ſpread out: wine is poured into them, ſo as to fill the one completely, the other only half. The fermentation commences in the latter. When it is well eſtabliſhed, this veſſel is filled from the wine contained in the firſt. By this means the fermentation abates, in the full veſſel, and commences in that which is half empty. When it has arrived at a conſiderable degree, the latter veſſel is again filled

with the liquor of that which had fermented the firſt; ſo that the fermentation, which follows the inverſe proportion of the maſſes, recommences in this and abates in the other. The two veſſels are thus alternately filled and emptied, till the vinegar is entirely formed, which generally requires from twelve to fifteen days.

SECTION II.

Of other Proceſſes by which acetous Acid is obtained.

7. The acetous acid differs from the product of the vinous fermentation in the circumſtance that it may be formed without this fermentation, that frequently it is the conſequence of alterations, or of changes independent of the acid fermentation. The proceſſes of the acetification, or of the converſion of the inſipid, ſaccharine, mucous, extractive vegetable matters into real acetous acid, are very numerous; and there have been obſerved, eſpecially for fifteen years paſt, a multitude of different circumſtances in which thoſe matters become acidified without experiencing any thing really ſimilar to a fermentation.

8. Theſe inſipid, or ſapid, but not acid matters, become ſo, and all become partly converted into the ſtate of acetous acid, by the ſpontaneous action which the ſulphuric acid exerts upon them. I have already ſeveral times obſerved, that the

mere tendency of the concentrated ſulphuric acid to ſaturate itſelf with water, is a very potent cauſe of alteration which it cauſes the vegetable matters to undergo. This alteration conſiſts in three diſtinct though ſimultaneous effects; firſt, a portion of the hidrogen of theſe matters unites with a portion of oxigen alſo belonging to them, to form water which ſaturates the acid; ſecondly, carbon is ſeparated, which renders the mixture brown and even black, and is ſoon precipitated to the bottom of the acid: at the ſame time that a third portion of theſe matters paſſes into the ſtate of acetous acid, which remains confounded with the ſulphuric acid, and may be ſeparated from it by diſtillation; ſo that there is no vegetable ſubſtance which, after having been treated in the cold by this powerful acid, does not yield more or leſs acetous acid, when afterwards ſubjected to the action of the fire.

9. The nitric acid which, as I have elſewhere ſhown, has a very active tendency to deſtroy the vegetable compounds, forms in them always a ſmall quantity of acetous acid, and at the ſame time the mucous and oxalic acids, and perhaps even malic acid. It has been ſeen that alcohol itſelf is in part converted into acetous acid, when treated by the acid of nitre. The muriatic acid alſo effects a ſimilar converſion when left for a long time with vegetable ſubſtances, though it is much leſs powerful than the ſulphuric and nitric acid. But it is moſt eſpe-

cially the oxigenated muriatic acid which, notwithſtanding its little ſolubility, when received in the ſtate of gas into the vegetable liquids or the ſolutions of vegetable matters, has the property of converting part of them into acetous acid. Thus when alcohol is treated with this agent it is converted much more into acetous acid than into ether, and it is on this account that the muriatic ether is always acid and little abundant.

10. It is not yet ſo well proved as has been thought, that moſt of the other vegetable acids are ſuſceptible of paſſing into the ſtate of acetous acid, and that this acid is the common term of their acidification. Though the tartarous acid appears actually to paſs into this ſtate, as well as the malic acid, and though from the conſtant preſence of the tartarous acidule in wine, it may be regarded as a ferment that promotes its acetification, and as furniſhing a ſubſtance which of itſelf becomes acetified, it ſeems that we cannot affirm the ſame of the oxalic acid, the ſtrongeſt and the moſt unalterable of the vegetable acids, which reſiſts all ſpontaneous alteration, in the ſame circumſtances in which the tartarous acid and the tartrites are decompoſed and deſtroyed.

11. We have juſt ſeen that acetous acid is formed in circumſtances different from fermentation, and that its production does not neceſſarily require the exiſtence of an inteſtine fermentative motion; there is alſo an acetous fermentation, whereby acetous acid is produced,

without its having been preceded by the vinous fermentation, the previous exiſtence of which was admitted after Boerhaave as indiſpenſible; ſo that the name of vinegar ought now to be applied only to the wine itſelf become acid or ſour, and that of acetous acid, which muſt preſent a more general idea than the word *vinegar*, ſubſtituted inſtead of it. Almoſt all vegetables are ſuſceptible of paſſing actually into the acid or acetous fermentation, of yielding real acetous acid, without having previouſly undergone the vinous fermentation, without having firſt formed wine. This is what happens with leaves and roots, with cabbage that has turned ſour in water, with *ſour crout*, which has been ſo improperly called in French *choux croute;* ſtarch or flour ſteeped in water, and forming the *ſour water of the ſtarch-makers*; dough itſelf, which, when it is ſuffered to riſe a little too ſtrongly, becomes ſour, and gives a very perceptible taſte to the bread that is produced from it.

12. It was formerly believed that, even in the caſes which I have juſt mentioned, an inſenſible vinous fermentation firſt took place, and that all the vegetable ſubſtances that turned ſour commenced with being in a vinous ſtate; but we here manifeſtly diſcern the influence of a prejudice which, after the theory of Boerhaave, forced nature, as it were, to adapt itſelf to the ideas that had been formed. We cannot admit a vinous fermentation, of which we have no proof and no indication, in the ſap of

trees at the moment when it has juſt been extracted, in extracts rapidly prepared, all of which contain acetous acid. The human urine and that of the animals aſſuredly do not experience a vinous fermentation, and yet they eaſily yield this ſame acid by an inteſtine change of their own matter: we may therefore conclude that there exiſts an acetous fermentation independent of the vinous, that it is not its neceſſary conſequence, and a formation of acetous acid in matters which are not in the vinous ſtate.

SECTION III.

Of the Properties of Vinegar.

13. VINEGAR, or that impure kind of acetous acid, which is moſt conſtantly prepared and uſed, and which is made by the acetous fermentation of wine, is a reddiſh or yellowiſh liquor, called *white wine vinegar,* when of the latter colour, of a ſour, pungent taſte, which is pretty ſtrong and agreeable, of a ſlightly aromatic ſmell, and retaining a portion of the alcohol of the wine not decompoſed. It weighs from 10,135 to 10,251; water being 10,000. It varies much in its properties, accordingly as it is obtained from a wine more or leſs ſpirituous, coloured, ſtrong, and generous, or weak and of bad quality. I do not here even ſpeak of that to which ſulphuric or

nitric acid has been added, in order to give it more acidity.

14. This common liquor contains, beſides the acetous acid, properly ſo called, a certain quantity of tartar, which it does not depoſit as wine does, a colouring extractive matter, ſometimes even a little mucilage, and frequently a portion of the malic and citric acids. We likewiſe find in it ſulphate of pot-aſh, and even a little ſulphate of lime. It may be ſuppoſed, however, that all theſe properties vary according to the nature of the wine from which it is obtained, and that therefore no two quantities of vinegar are perfectly alike. Accordingly the combinations of this acid are not what are uſually examined by chemiſts.

15. Vinegar contains or nouriſhes a ſpecies of microſcopic animals, which have been very improperly termed *eels*, and are of the kind called animalcules of infuſion. Modern naturaliſts have given this ſpecies the name of *vibrio aceti.* It exhibits a much more conſiderable quantity of them when it begins to change, and it is very ſuſceptible of alteration. We ſee it become turbid, much flocculent ſediment ſubſides in it, it acquires a mouldy ſmell, and even forms a mucous and glutinous maſs, reſembling what is called mother of vinegar. It is well known that it undergoes this decompoſition much more ſpeedily when it is left upon its lees, for which reaſon it is racked off immediately after it is made. It appears, that tartar is

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one of the ſubſtances contained in vinegar, which contributes moſt to its ſpontaneous alteration; for the phenomena that take place in this decompoſition are the ſame as thoſe in a ſolution of tartar.

16. When vinegar is expoſed to froſt, there is only a portion of it freezes: the frozen part is little more than water, and the part not frozen is ſtrong vinegar. If this congelation be repeated, gradually increaſing the intenſity of the cold each time, very little unfrozen vinegar will be obtained: this is very ſtrong, leſs coloured, leſs liable to change, and much more eaſy to keep: it is called *vinegar concentrated by froſt.* This is one mode of keeping it; but it is very expenſive, becauſe little is left that does not freeze. Scheele has diſcovered a much better proceſs for rendering it capable of being kept: this conſiſts in boiling it for a few minutes. After this operation, vinegar is much leſs liable to alter, and may be kept even in open veſſels without ſpoiling: it is evidently very ſimple, and very applicable to domeſtic purpoſes.

17. The action of fire on vinegar is employed to obtain pure acetous acid. For this purpoſe it is diſtilled in a ſtone cucurbit with a glaſs head, or in a glaſs retort placed in a ſand-heat, with a receiver adapted to it. It muſt be heated ſlowly, and only ſo as to make the vinegar boil gently At firſt a liquor of a quick, fragrant, aromatic ſmell, paſſes over, the firſt portion of which is

alcohol mixed with a little acetous acid. To this ſoon ſucceeds a very pale acid liquor, of a ſtrong acid ſmell, which is the acetous acid, or diſtilled vinegar. As the diſtillation proceeds, the more acid it becomes, having leſs ſmell with more acidity: all theſe products may be obtained ſeparately, by changing the receiver at each; but this is ſeldom done. When the operator has drawn off about two-thirds of the liquor he expoſed to diſtillation, he puts an end to the proceſs: if more be drawn off, it will have an empyreumatic ſmell. After this product is obtained, what remains of the vinegar is a thick liquor, of a deep and dirty red colour; it depoſits a certain quantity of acidulous tartrite of pot-aſh; it is ſtill very ſour: it contains therefore acids more fixed than the acetous, which occaſions the acrid and empyreumatic ſmell ariſing from burned vinegar. This extract, diſtilled in a retort, yields ſome coloured acid water, brown oil, and a little ammonia, leaving behind a coal which contains a great quantity of pot-aſh.

SECTION IV.

Of the Chemical Properties of Acetous Acid.

18. I HAVE aſſerted, that chemiſts did not examine the properties of vinegar in its common ſtate; that, to diſcover the character of the

acetous acid, they make uſe of that which they have extracted from vinegar by diſtillation: accordingly the combinations I am proceeding to examine, are thoſe of this pure acid. The acetous acid in this ſtate, poſſeſſing perfect tranſparency, of a ſufficiently agreeable ſmell, of a pungent ſour taſte, of a ſpecific gravity ſenſibly leſs than that of vinegar, ſince it reaches only 10,005, reddening blue vegetable colours, if expoſed alone to heat is volatilized, and evaporated intirely. It is more volatile than decompoſable: it keeps without alteration in cloſe veſſels: it does not act on hidrogen, carbon, phoſphorus, nor ſulphur: it unites with water in any proportion. We are not yet well acquainted with the manner in which it is affected by the powerful acids, though we know that concentrated ſulphuric acid, carbon, and nitric acid, decompoſe it into carbonic acid and water. It weakly diſſolves boracic acid, and abſorbs carbonic acid.

19. The acetous acid unites with all the earthy and alkaline baſes, and the ſalts it forms are characterized by their great ſolubility, their decompoſition by fire which converts them into coal, the ſpontaneous alteration of their ſolutions, and their decompoſition by a great number of acids, which diſengage from them the acetous acid in a very concentrated ſtate.

The following are the characteriſtic properties of the principal ſpecies of acetites hitherto examined.

amined. The order in which they are arranged, founded on the affinities of the acetous acid, is the ſame with that obſerved in a great number of foſſil ſalts.

A. The acetite of barites cryſtallizes in needles; its taſte is bitter; it effloreſces in the open air; it is very ſouble; it is decompoſable only by the alkaline carbonates, and not by the pure alkalis or earths. It may be employed to detect the preſence and quantity of ſulphuric acid in vinegar ſophiſticated by this addition.

B. The acetite of pot-aſh exiſts in ſeveral vegetable juices; it has been ſeen, that all the extracts contain it; Citizen Vauquelin has found it in dunghills, and in mould; it has been diſcovered in ſaps; it is even ſeparated from the urine of ſome quadrupeds. It is prepared for pharmaceutical purpoſes; and was long called *foliated earth of tartar*, becauſe it was obtained in a dry foliaceous and not cryſtalline form. The preparation of this ſalt, which is much uſed in phyſic, conſiſts in ſaturating carbonate of the pot-aſh with acetous acid added to it in exceſs, filtrating the liquor, evaporating it over a gentle fire in a porcelain or ſilver veſſel, finiſhing the evaporation to dryneſs when the liquor is become thick, on a water-bath, or on hot aſhes. By theſe means a white ſalt is obtained: but if the evaporations were conducted over a ſtrong fire, the ſalt would become grey or brown, becauſe a part of the vinegar would burn.

The acetite of pot-aſh has a pungent acid taſte, becoming urinous and alkaline as it goes off. In the fire it melts, ſwells, decompoſes, and burns to a coal. Diſtilled in a retort, it yields ſome acid water, an empyreumatic oil, a little ammonia, and much carbonated hidrogen gas and carbonic acid gas. The coal which remains after this diſtillation contains pot-aſh uncombined, and frequently it is in the pyrophoric ſtate.

The acetite of pot-aſh ſtrongly attracts the moiſture of the air: it is extremely ſoluble in water, and produces cold as it diſſolves: its concentrated ſolution affords, though with difficulty, regular priſmatic cryſtals, but they are of very little permanence, on account of their deliqueſcency. The ſame ſolution, a little more diluted in water, is decompoſed ſpontaneouſly in cloſe veſſels: it depoſits a thick flocculent mucus, of a grey colour, and at laſt black; and a the end of a few months contains only carbonate of pot-aſh, ſoiled with a little carbonaceous oil. In this property it reſembles tartrite of pot-aſh.

The acetite of pot-aſh is decompoſable by the powerful acids. Diſtilled with concentrated ſulphuric acid, it yields an extremely acrid acetous acid, which, on account of its ſmell, has even been confounded with the acetic acid, of which I ſhall ſpeak hereafter. The tartarous and oxalic acids likewiſe decompoſe the acetite of pot-aſh, and they are ſtronger than the acetous acid. We ſhall ſee further on, that this ſalt precipitates ſeveral metallic ſolutions by the help of the double affinities. When it is diſtilled with arſenious acid, or white oxide of arſenic, it yields a volatile, fuming product, of a horribly fetid ſmell, and which takes fire ſpontaneouſly in the open air, giving out a copious ſmoke and a reddiſh flame.

C. The acetite of ſoda has been very improperly named *mineral foliated earth*, ſince this denomination ought not to have been given, even in the ancient nomenclature, to a very cryſtallizable ſalt. It is prepared by ſaturating carbonate of ſoda with acetous acid. The filtered ſolution is evaporated to a ſlight pellicle, and on refrigeration it forms ſtriated priſmatic cryſtals, ſomewhat like thoſe of ſulphate of ſoda depoſited rapidly. This ſalt is bitter, pungent, and mixed with a taſte at firſt acid, afterward alkaline. It is decompoſed in the fire, like the preceding, and ſpontaneouſly in its aqueous ſolution. It is not like it, deliqueſcent: it leaves however a pyrophoric reſiduum after diſtillation. It is decompoſable by barites and pot-aſh.

D. We are yet very little acquainted with the acetite of ſtrontian: we know only that this combination has a ſweet taſte, that it is very ſoluble, and that it is eaſily decompoſed by a ſtrong heat.

E. The acetous acid combines eaſily and readily with lime: it diſſolves the carbonate of lime with effervefcence: when it is faturated with it, and when the folution is evaporated to a pellicle, it yields cryftals in very fine prifms, in a fort of fhining fatin-like needles. This falt is acid and bitter: it effloreſces in the air, like the acetite of barites: it is decompoſed by this baſe, as well as by the two fixed alkalis. The powerful acids expel the acetous from it with effervefcence, as from all the other acetites. It decompoſes feveral falts by double affinity. The acetite of lime is frequently obtained in chemical analyſis, on treating with acetous acid the reſiduums of mineral waters, and different earths or ſtones divided by fuſion with pot-aſh.

F. The acetous acid unites readily with ammonia: this fluid combination, with exceſs of acetous acid, forms the *ſpirit of mindererus* prepared in the ſhops. It is the ammoniacal acetite. On evaporating it, to endeavour to obtain cryſtals, it volatilizes intirely: hence ſome chemiſts have propoſed to prepare it by diſtillation. It is thus that it is extracted from dunghill waters, from ſome fermented ſaps, and even from altered wines. Some have affirmed, however, that they have obtained a few needled cryſtals of it, of a warm pungent taſte, and very deliqueſcent. This ſalt is decompoſed by fire, by the acids, by the alkalis, and by ſeveral earthy baſes; it undergoes ſpontaneous deſtruction.

G. The acetite of magneſia is very eaſily prepared by the direct union of acetous acid with carbonate of magneſia, which it diſſolves with effervefcence. It cryſtallizes but very difficultly, and its ſolution yields when evaporated, a viſcous, deliqueſcent maſs. By this property it is eaſily ſeparated from the acetite of lime, with which it is frequently confounded in the dry form, in the product of the evaporation of the earthy reſiduums of mineral waters treated by acetous acid. This ſaline maſs, always ſatiny and ſhining, attracts moiſture, and diſſolves in the open air. As long as it contains any acetite of magneſia, this is gradually ſeparated as it liquefies; and when no farther deliqueſcence takes place, the remainder is pure acetite of lime.

The acetite of magneſia, beſides the generic properties of the acetites, is decompoſable by barites, the fixed alkalis, ſtrontian, lime, and partly by ammonia.

H. The acetous acid diſſolves glucine very well. This ſolution, according to Citizen Vauquelin, does not cryſtallize: it is reduced by evaporation to a gummy ſubſtance as it were, which ſlowly dries and becomes brittle, but long retains a ſort of ductility. Its taſte is ſaccharine, and pretty ſtrongly aſtringent; yet it permits us to diſtinguiſh that of vinegar.

I. This acid diſſolves alumine very difficultly: it forms with it little needly cryſtals, ſoft, ſenſibly aſtringent, and decompoſable by all the preceding baſes. We yet know little of the properties of acetite of alumine.

K. It is the ſame with the acetite of zircon. It has been very little examined hitherto: all that we know is, that this ſaline combination exiſts; and that it is gelatinous, and decompoſable by all the alkaline and earthy baſes with which we are acquainted.

20. The acetous acid acts on a great number of metallic ſubſtances, and in its combination with theſe exhibits phenomena more or leſs important for us to know, or compounds more or leſs uſeful.

21. It has no action on arſenic, and does not diſſolve the arſenious acid: yet this acid, being diſtilled with an equal quantity of acetite of pot-aſh, afforded Citizen Cadet and the chemiſts of the academy of Dijon, a red, fuming liquor, of a very noiſome ſmell, very tenacious, and of a very ſingular nature. Citizen Cadet had already obſerved, that this liquor was capable of inflaming fat lute. The academicians of Dijon, deſirous of examining the yellowiſh matter of an oily conſiſtence, collected at the bottom of the veſſel that contained the fuming arſenico-acetous liquor, decanted a portion of the ſupernatant fluid, and poured the reſt on a paper filtre. Scarcely had a few drops paſſed through, when on a ſudden aroſe a very denſe noiſome vapour, which formed a column from the veſſel to the cieling; a kind of ebullition took place about the edges of the matter, and a fine roſe-coloured flame iſſued from it, which continued a few inſtants. This liquor, which the

chemiſts of Dijon compared to a liquid phoſphorus, is a ſort of pyrophorus like thoſe which will be mentioned hereafter. The reſiduum of the diſtillation of the acetite of pot-aſh with arſenious acid conſiſts of pot-aſh chiefly.

22. The acetous acid diſſolves cobalt in the ſtate of oxide, and forms a ſolution of a pale roſe colour, which yields no cryſtals, but the properties of which are not known.

23. It has no action on biſmuth, or on its oxide, but it diſſolves the oxide of manganeſe. We know nothing of its action on titanium, uranium, tungſten, molybdena, or chrome.

24. According to Arwidſon, it diſſolves nickel directly: this ſolution affords green cryſtals, in figure reſembling a ſpatula.

25. This acid does not act on antimony; but it appears to diſſolve the vitreous oxide of this metal, ſince Angelus Sala made an emetic preparation with theſe two ſubſtances.

Its action on tellurium is unknown.

26. Zinc, as well as its oxide, diſſolves very readily in acetous acid. Citizen Monnet has obtained cryſtals in flat laminæ from this ſolution by evaporating it. The acetite of zinc fulminates on burning coals, and gives a ſmall blueiſh flame after melting and ſwelling up. By diſtillation it yields an inflammable liquor, a yellowiſh oily fluid, which ſoon becomes of a deep green, and a white ſublimate, which burns in the flame of a candle with a fine blue colour. The reſiduum is in the ſtate of a pyrophorus but

little combuſtible. Hence we ſee vinegar muſt diſſolve the kind of tinning made with zinc. Dr. Laplanche has proved, that the acetite of zinc is not dangerous to the animal economy.

27. Acetous acid does not diſſolve quickſilver in the metallic ſtate. This combination however is effected by agitating it ſtrongly by means of whiſks or agitators, as Keyſer did. In this operation the quickſilver is firſt converted into black oxide, and afterward diſſolved in the acid.

Quickſilver in the ſtate of oxide is eaſily united with the acetous acid. It is ſufficient to boil this acid on the red oxide of mercury, called precipitate *per ſe*, or turbith mineral, or on mercury precipitated from its nitric ſolution by pot-aſh. The liquor becomes white, and grows clear when it boils; it is then to be filtered: on refrigeration ſilvery cryſtals are precipitated from it in little ſpangles, or in ſtriated laminæ ſimilar to the boracic acid. This acetite of quickſilver has been called foliated earth of mercury. It is prepared extemporaneouſly by pouring a nitric ſolution of quickſilver into a ſolution of acetite of pot-aſh: the nitric acid unites with the fixed alkali of the latter ſalt, forming with it nitre, which remains diſſolved in the liquor; and the oxide of mercury, combined with the acid of vinegar, precipitates at firſt in a yellowiſh white powder, and afterwards in the form of ſhining ſpangles, particularly if the liquor be evaporated. The mixture being filtered, the acetite of mercury remains on the filter. This ſalt is decompoſed by the action of fire: its reſiduum yields a ſort of pyrophorus. It is eaſily altered by combuſtible vapours; is acrid, and is not very ſafe as a medicine.

28. Tin is little altered by the acetous acid. This acid diſſolves but a ſmall quantity of it, and the ſolution, when evaporated, yields according to Citizen Monnet a yellowiſh cruſt, ſimilar to a gum, and of a fetid ſmell.

29. Lead is one of the metals on which the acetous acid has moſt action. This acid oxides it, and diſſolves its oxides with the greateſt facility. On expoſing ſheets of this metal to the vapour of warm vinegar, they become covered with a white powder, called *ceruſe*, which is nothing but an oxide of lead containing a little vinegar. This oxide, ground with a third part of chalk, forms *white lead.* To ſaturate vinegar with all the oxide of lead it can diſſolve, this acid is poured on ceruſe in a matraſs: the mixture is digeſted in a ſand-heat: the liquor is filtered, after it has ſtood in digeſtion ſome hours: it is then evaporated to a pellicle: and it furniſhes, by refrigeration and repoſe, white cryſtals, which are ſhapeleſs needles, if the liquor were too much concentrated, and flattened parallelopipeds, terminated by two bevilled ſurfaces, if the evaporation were properly conducted. This acetite of lead has been called *ſalt* or *ſugar* of *ſaturn* on account of its ſaccharine taſte, which is at the ſame time ſlightly ſtyptic.

A ſimilar ſalt is prepared with the vitreous oxide of lead, or litharge, and vinegar. Equal parts of theſe two ſubſtances are boiled together to ſaturation; evaporated to the conſiſtence of a thin ſyrup; and we have then *Goulard's extract of ſaturn,* known long before his time by the name of vinegar of ſaturn.

The acetite of lead is decompoſed by heat: on diſtillation it affords an acid, red, very fetid liquor, differing greatly from the acetic acid, which will be mentioned preſently. The reſiduum of the diſtillation is a very good pyrophorus. This ſalt is decompoſed by diſtilled water, by lime, the alkalis, and the acids with ſimple radicals, as well as by ſeveral vegetables, which yield with it inſoluble ſalts; and mixed with a little brandy it forms the vegeto-mineral water.

30. The acetous acid diſſolves iron with activity. The efferveſcence that takes place in this ſolution is owing to the diſengagement of hidrogen gas furniſhed by the water, which is decompoſed. The liquor aſſumes a red or brown colour. By evaporation it yields only a gelatinous magma, mixed with ſome brown elongated cryſtals. The acetite of iron has a ſtyptic and ſweetiſh taſte: it is decompoſed by heat, and lets its acid eſcape: it attracts the moiſture of the air: it is decompoſed in a large quantity of diſtilled water. When it is heated till it yields no more ſmell of vinegar, it leaves a yellowiſh oxide, eaſily reducible, and attracted by the magnet. The acetous ſolution of iron yields a very black ink

with galls, and may be employed with ſucceſs in dyeing: alkaline pruſſiates precipitate from it a very brilliant Pruſſian blue: pure alkalis, in particular ammonia, ſeparate the iron from it in the ſtate of an oxide almoſt black, and this precipitation has been propoſed for preparing the *martial ethiops*. The black, yellow, and brown oxides of iron, and the native carbonate of iron, or ſparry iron ore, afford very fine red ſolutions with acetous acid.

31. Copper is oxided and diſſolved with great facility in the acetous acid. The ſolution of this metal, aſſiſted by heat, gradually aſſumes a green colour: but this is more eaſily produced with the metal already altered and oxided by vinegar. Copper thus oxided, is the *verdet gris*, or verdigris. It is prepared in the neighbourhood of Montpelier by putting ſheets of thin metal into earthen pots with grape ſtalks, which had been previouſly wetted and ſet to ferment with the reſiduum left after diſtilling brandy from wine. The ſurface of theſe ſheets is ſoon covered with a green ruſt, which is increaſed by placing them in heaps, and ſprinkling them with vinegar: the copper is then ſcraped, and the verdigris is packed up in ſkin bags as an article of trade. Montet, an apothecary at Montpelier, has very well deſcribed this manufacture in two Memoirs printed among thoſe of the Academy of Sciences in 1750 and 1753.

Citizen Chaptal has made known to the Inſtitute the improved proceſſes at preſent employed for this preparation. It has been remarked that the acetite of copper was formerly prepared with dried grape-ſtalks, which were ſoaked for a week in the liquor left after diſtilling brandy from wine, and afterward ſet to drain in a baſket: theſe were put into an earthen pot, called an *oule*, and four litres of wine were poured in, with which the ſtalks were well impregnated by ſtirring and ſqueezing them with the hand in the liquor: as ſoon as the fermentation and heat ſubſided, the ſtalks were taken out, and laid in layers with the ſheets of copper.

At preſent we take the grapes from which the juice has been preſſed; put them into a caſk, raiſing them up and giving them air; ſet them to ferment; and place them with ſheets of copper, ſtratum ſuper ſtratum, in earthen pots or *oules* made for this purpoſe. In ten or fifteen days the copper ſheets will be covered with little ſilky cryſtals; and then they are placed edgewiſe on rods arranged for the purpoſe in a corner of the manufactory. After remaining thus three or four days, they are dipped in water, and replaced on the rods. This immerſion and deſſiccation are repeated once a week for near two months: and then the coat of verdigris, that covers both ſides of each ſheet of copper, is ſcraped off with a wooden knife. It is obvious, that this latter proceſs which is generally adopted, has every advantage: inſtead of conſuming a large quantity of wine like the former, it requires only a product of no value.

Verdigris diſſolves ſpeedily in acetous acid. This ſolution, which is of a fine greeniſh-blue colour, furniſhes by evaporation and refrigeration deep blue cryſtals in truncated quadrangular pyramids, to which have been given the name of *verdet*, or *cryſtals of Venus*. Thoſe that are prepared as an article of trade, and called diſtilled verdigris, becauſe they are made with diſtilled vinegar, are in the form of a beautiful pyramid: the cryſtals arranging themſelves in this manner, becauſe they are depoſited on a ſtick cleft in four at one end, and the parts kept ſeparate by a bit of cork. Citizen Chaptal recommends it to be prepared by mixing a ſolution of ſulphate of copper with a ſolution of acetite of lead; when a ſulphate of lead would be precipitated, which might be uſed for white lead, and the ſupernatant liquor would contain acetite of copper, which might be obtained by evaporation.

This ſalt has a ſtrong taſte, and is very poiſonous. It is efloreſcent, very ſoluble, and decompoſable by all the alkalis. Expoſed to the fire, and by diſtillation, it gives out its acid in a peculiar ſtate, which will be mentioned farther on.

32. The acetous acid diſſolves oxide of ſilver, of gold, and of platina, particularly by the aſſiſtance of heat. Theſe acrid and cauſtic ſolutions are decompoſed by fire, by alkalis, by the hidro-ſulphurets, and hidrogenized ſulphurets. Bergman has remarked, that this acetous ſolution

of gold produces fulminating gold with ammonia. For the reſt, this acid has no action on theſe three metals, the leaſt oxidable of any known, whatever the alchemiſts have ſaid.

33. Vinegar is capable of uniting with many of the immediate materials of vegetables. It diſſolves the extracts, mucilages, and eſſential ſalts: it even acts a little on the gum-reſins and oils: it is eaſily united with the extractive and colouring matters of vegetables, ſo as to acquire their taſte, ſmell, and medicinal or agreeable properties. On this is founded the art of making medicinal vinegars, vinegars for the table and the toilet, and aromatic vinegars, by ſimple infuſion or diſtillation: the pretence formerly held out of fabricating very important medicinal vinegars by fermenting medicinal herbs with wine has long been exploded as an error.

Vinegar likewiſe diſſolves very readily the gluten of wheaten flour; and we may ſeparate this ſubſtance, with its elaſticity and characteriſtic properties, from this ſolution, even after it has been kept ſeveral years, by means of alkalis.

SECTION V.

Of the different Modifications or Species of Acids afforded by Vinegar.

34. IT has been ſeen by the detail of the properties hitherto deſcribed, that the acid of vinegar is liable to be found in certain peculiar modifications, and that it might be diſtinguiſhed in each of theſe, if not as a ſeparate ſpecies, yet as a variety deſerving a ſpecial and determinate denomination. Thus to the word vinegar we add thoſe of *concentrated by froſt*, to diſtinguiſh that which has been deprived of part of its water by congelation; and the word *boiled*, to indicate that conſervatory effect, which a few minutes of ebullition produce in it. Thus alſo the expreſſion of *acetous acid*, *ſynonimous* with that of *diſtilled vinegar*, diſtinguiſhes and ſufficiently characterizes its nature, ſo as to leave no room for miſtake reſpecting them.

35. No doubt freſh obſervations, made with much care, will hereafter lead us to conſider as a particular variety of this acid that which is obtained by the diſtillation of earthy or alkaline acetites, and that which is expelled by heat from the acetite of lead. But of all the modifications of this acid, that which has been hitherto moſt carefully diſtinguiſhed, moſt ſtudied, and has in

fact exhibited to the obſerver the moſt ſtriking and remarkable differences, is the product of the decompoſition of the cryſtallized acetite of copper by means of heat.

36. When this ſalt reduced to powder is diſtilled in a glaſs or earthen retort with a receiver, a fluid is obtained, at firſt clear and of little acidity, but which ſoon acquires a conſiderable degree, inſomuch that it ſeems to equal the concentration of the mineral acids. The receiver is changed, in order to have theſe two products ſeparate; the latter of which has been called radical vinegar, or vinegar of Venus. This acid is coloured green by a certain quantity of oxide of copper, which it carries over with it in diſtillation. When nothing more comes over, and the retort is red-hot, the reſiduum this contains is in the form of a brown copper coloured powder, and often gives to the ſides of the veſſel the ſhining appearance of this metal. The reſiduum is ſtrongly pyrophoric: it contains but little oxide, with a little charcoal.

The vinegar of Venus is rectified by diſtillation with a gentle heat. It is then perfectly pale and clear, if we take care that the fire be not too ſtrong toward the end of the operation, and that the portion of oxide of copper, which remains in the retort, be not too much dried.

37. The reduction of the copper, obſerved in this experiment, elucidates the nature of the radical vinegar. It was formerly obſerved, that this acid is to common vinegar what the oxigenated

muriatic acid is to the pure muriatic, or rather what the ſulphuric acid is to the ſulphureous, and the nitric acid to the nitrous. In this operation, the acetous acid appeared to unite with the oxigen of the oxide of copper, which at the ſame time paſſed to the metallic ſtate. The effects produced by radical vinegar, differing conſiderably from thoſe of common vinegar, ſeemed therefore owing to the exceſs of oxigen, which this acid had acquired. Such was the theory adopted by Citizen Berthollet: and it was on this account that the acid was called acetic, conformably to the rules of nomenclature ſo often exhibited in this work.

But Citizen Perès, a druggiſt, firſt began publicly to expreſs doubts reſpecting the compound nature of this acid; and to affirm, both from ſeveral facts already known but more accurately compared by him, and from ſome experiments of his own, that the only difference exiſting between this acid and the acetous might very well be aſcribed to the proportion of carbon being leſs in the former, and greater in the latter.

At the end of the year 6, Citizen Adet read at the Inſtitute a Memoir on the difference of theſe two acids, in which he deſcribed ſeveral new experiments on the diſtillation and products of acetite of copper, on the treatment of the acetous acid by oxide of manganeſe, and on the combinations of the acetic acid compared with thoſe of the acetous. After having ſhown, that water and carbonic acid are formed, and that carbon is left bare, during the diſtillation of acetite of copper; that the acetous acid diſtilled upon oxide of manganeſe never becomes oxigenated; that the acetic acid united with metallic oxides does not comport itſelf differently from the acetous acid; that the acetic acid does not attack metals any more than the acetous; and that the ſalts formed by the two acids with earthy and alkaline baſes exhibit but very ſlight differences; he thought himſelf warranted to conclude from his labours: 1ſt, that the acid of vinegar abſorbs no oxigen in its combination with oxide of copper, and does not exhibit itſelf in two different ſtates: 2dly, that it is always in the higheſt degree of oxigenation, and always in the ſtate of acetic acid, even in that of diſtilled vinegar, hitherto called acetous acid: 3dly, that no acetous acid properly ſo called exiſts, unleſs we think fit to give this name to the tartarous and malic acids, which become acetic acid by the addition of oxigen: 4thly, that there exiſt no acetites, but only acetates: 5thly, and laſtly, that the difference between what have hitherto been called *acetous* acid and *acetic* acid appear to him to depend ſolely on the concentrated ſtate of the former, and its containing a much ſmaller quantity of water than the latter.

38. But this concluſion of Citizen Adet appears in truth a little forced, and not reſtricted with the preciſion expreſſed in the experiments preceding it. In fact, we cannot avoid perceiving differ-

ences between the two acids announced in the experiments of Citizen Adet himſelf, particularly in their combinations: differences of which this chemiſt profeſſes that he ſhall endeavour to inveſtigate the cauſe.

Laſtly, Citizen Chaptal has employed himſelf on this ſubject; and about a month after the publication of Citizen Adet's labours, he communicated to the philomathic ſociety ſome obſervations and experiments, whence he conceived himſelf juſtified in drawing inferences ſomewhat different from thoſe of Citizen Adet. The acetous and acetic acids, previouſly reduced to the ſame degree of ſpecific gravity and concentration by means of water, preſented a great difference in ſmell and taſte: the acetic, which was much more acrid, formed a well cryſtallized ſalt with oxide of copper; the acetous became ſcarcely tinged, of a bluiſh-green, and afforded only a ſaline cruſt: the acetous required one ſixth leſs of pot-aſh to ſaturate it than the acetic. On diſtilling each with a fourth of its weight of ſulphuric acid, the mixture of acetous acid became coloured of a deep red, that of acetic of a ſtraw-colour: the acetous, leaving charcoal in the retort, came nearer to the acetic: the acetite and acetate of pot-aſh being both evaporated to dryneſs, and alike diſtilled by a fire, graduated ſo as to decompoſe them completely, the former left a thirteenth of its weight, the latter a ſeventeenth. On diſtilling the acetite of copper, a portion of the carbon of the acetous acid attacks the oxigen of the oxide of copper, and flies off in carbonic acid; another remains in its natural ſtate with the copper: thus the acetous acid paſſes to the acetic ſtate by loſing a part of its carbon, which the acids or metallic oxides ſeparate from it.

Citizen Chaptal concludes from theſe experiments, that the acetous and acetic acids really differ from each other, in the former containing more carbon than the latter; that the acetous acid becomes acetic only by parting with carbon; and that the modification depends only on the ſubtraction of carbon, or diminution of the radical, not on the addition of oxigen, or the augmentation of the acidifier, as takes place in acids with ſimple radicals.

In fact it is to be remarked here, that the binary hidro-carbonated radical of this acid muſt undergo a change, when the proportion of carbon in it is diminiſhed; that after this it no longer contains in reality the ſame radical; that conſequently it is not poſſible to make it again return to the ſtate of acetous acid; but that nevertheleſs the acid thus decarbonated may ſtill be conſidered as an acid more oxigenated than the acetous, ſince the proportion of the acidifier is in fact augmented by diminiſhing that of the carbon, and that therefore it ought to retain the appellation of acetic acid. We ſhall proceed to deſcribe its diſtinguiſhing properties.

39. The acetic acid well rectified is of ſuch a briſk and penetrating ſmell, that it is impoſſible

to ſupport it for any time: it is ſo cauſtic, that, if applied to the ſkin, it burns and corrodes it: it is extremely volatile and even inflammable: heated in contact with air it inflames and burns with more or leſs rapidity, accordingly as it is more or leſs dry and rectified. This experiment has led chemiſts to believe, that the products of vinegar contain alcohol, and ſeem to be a ſort of native ether. This idea agrees with the penetrating and agreeable ſmell, which the firſt portions of this diſtilled acid diffuſe. The acetic acid evaporates entirely in the air: it unites with water, generating much heat: with earths, alkalis, and metals, it forms ſalts different from thoſe of common vinegar; and we call them the acetates of pot-aſh, ſoda, zinc, and mercury. Laſſone has ſhown, that the ammoniacal acetate differs from the ammoniacal acetite or ſpirit of mindererus; and though we have not yet a ſufficient knowledge of all the acetates, their form, taſte, and ſolubility ſufficiently ſhow that they are really different from the acetites.

Courtanvaux has proved, that only the laſt portion of acetic acid obtained in the diſtillation of the acetite of copper, or verdigris, is inflammable, and likewiſe poſſeſſes the property of congealing by cold. In the experiments of this chemiſt, the laſt rectified portion of the acid cryſtallized in the receiver in large laminas and in needles, and did not become fluid but at a temperature of thirteen or fourteen degrees above the freezing point. This property ſeems to indicate an analogy between the acetic acid and the oxigenated muriatic.

40. The acetic acid differs eminently from the acetous by its property of decompoſing alcohol, and forming ether, though in this its action is not to be compared with that of the powerful acids. It is to Citizen Lauraguais we are indebted for the diſcovery of the acetic ether. To obtain it, all that is neceſſary is, to pour acetic acid well rectified into a retort containing an equal quantity of alcohol. A conſiderable heat is excited. The retort is placed on a hot ſand-bath, and two receivers are adapted to it, the laſt of which is immerſed in cold water, or pounded ice; and the mixture is brought to boil quickly. At firſt dephlegmated ſpirit of wine paſſes over, afterward ether, and laſtly, an acid, which grows ſtronger in proportion as the diſtillation advances: a brown maſs, much reſembling reſin, remains in the retort. The operator takes care to change the receiver, as ſoon as the ethereal ſmell becomes acrid and pungent, and the acid is collected ſeparately. The acetic ether is rectified with pot-aſh by a gentle heat: in this ſecond operation a great deal is loſt.

Scheele ſays, that he could not ſucceed in preparing acetic ether by means of radical vinegar united with alcohol, and obtained it only by adding a mineral acid. Mr. Poerner had already made the ſame remark on the difficulty of obtaining acetic ether by the proceſs of Citizen Lauraguais. Yet many French chemiſts have repeated the proceſs; and I can affirm, that I have performed it myſelf with ſucceſs, though it is true I obtained but a ſmall quantity of ether, compared with what is formed by the powerful acids.

Citizen Laplanche, a druggiſt at Paris, prepares acetic ether by pouring concentrated ſulphuric acid and alcohol on acetite of lead introduced into a retort. The theory and practice of this operation, are preciſely the ſame with thoſe of the nitric and muriatic ethers prepared by a ſimilar proceſs.

The acetic ether has an agreeable ſmell like all the other ethers, but the ſmell of acetic acid may be diſtinguiſhed in it. It is very volatile and very inflammable: it burns with a vivid flame, and leaves a coally mark after combuſtion.

41. The action which acetic acid exerts on the immediate materials of vegetables has not been appreciated in compariſon with that of the acetous: if it have any different effects, they are no doubt owing to its activity and energy. It has not yet been uſed for any purpoſe in pharmacy or manufactures, ſo that we are altogether ignorant whether it have any thing diſtinct in its mode of action in theſe reſpects.

SECTION VI.

Of the Uſes of Acetous Acid.

42. EVERY one knows how much common vinegar is uſed for domeſtic purpoſes, and what important ſervices it renders ſociety: it is the moſt frequent and uſeful condiment that can be employed: it is mixed and united with all kinds of food, the inſipidity of which it conceals, or heightens their flavour. There are few perſons to whom it is not agreeable. It is drank mixed with water, and often in combination with ſugar or honey. The Romans made their ſoldiers drink water acidulated with vinegar, *poſca*, and to this cuſtom is aſcribed the permanent healthineſs of their armies. Notwithſtanding the benefits of vinegar, and its general uſe in ſeaſoning, the abuſe or exceſs of it is injurious: it diſorders the ſtomach, and enfeebles it, diſſolves and ſoftens the organic texture, and produces leanneſs. It is uſed as a preſervative againſt peſtilential diſeaſes. It enables us likewiſe to keep fruits, certain leaves, and ſeveral alimentary ſubſtances, which are left to macerate in it a longer or ſhorter time.

43. Phyſicians have greatly multiplied the uſes of vinegar as a medicine: it is refreſhing,

cooling, antiſeptic, anti-bilious. A very agreeable ſyrup is made of it: it is combined with honey; and to this preparation, called *oxymel*, ſquills are added, and even colchicum, to render it diuretic, aperitive, inciſive. Common vinegar is the vehicle of many medicaments: a great number of different plants are infuſed or macerated in it, to prepare the vinegar of ſquills and of meadow-ſaffron, aromatic, bitter, antiſcorbutic, and theriacal vinegar, and that of the four thieves. It is diſtilled with very aromatic plants, to obtain odoriferous vinegars, intended chiefly for the toilet. The various common preparations deſigned for the table, made by infuſions in vinegar, are well known; particularly elder vinegar, roſe vinegar, tarragon vinegar, garlic vinegar, and all the varieties that have been invented, to multiply the flavours and ſmells of this liquid.

44. The acetous acid, or diſtilled vinegar, is employed in a great number of pharmaceutical combinations. As the acetites of pot-aſh and ſoda, which are preſcribed as attenuants in doſes of a few grammes: the acetite of ammonia, which is adminiſtered as a cordial by the name of *ſpirit of Mindererus:* the acetite of quickſilver, called *foliated earth of mercury*, which forms the baſis of Keyſer's remedy for venereal diſeaſes: the acetite of lead, frequently preſcribed for external uſe in the medicaments, called *extract of ſaturn*, *ſalt*, or *vinegar of ſaturn*, *vegeto-mineral water*, *cerate of ſaturn*,

but

but which ought to be employed with great prudence and moderation. The moſt ſkilful and judicious phyſicians alone have a right to preſcribe ſuch compoſitions, which may do much miſchief in the hands of men ignorant of their effects; and much more ought we to be afraid of employing ceruſe, verdigris, and the cryſtallized acetite of copper; ſubſtances which ſcarcely enter into any preparations, a few ointments for external uſe excepted.

45. Theſe oxides and metallic ſalts, prepared with lead and copper by means of vinegar, are uſed for a great many purpoſes in the arts. For painting in particular they are in great demand. It muſt not be forgotten, that by employing them in the arts we expoſe ourſelves to very ſerious dangers, and to be poiſoned, if we be not very attentive.

46. The acetic acid is uſed as an irritant, and a very active ſtimulus. It is held to the noſtrils of perſons who faint; for which purpoſe a ſmall quantity is commonly poured on ſulphate of pot-aſh in coarſe powder, and kept in a well-ſtopped bottle: this preparation is very improperly called *ſalt of vinegar.*

The acetic ether is begun to be employed in practice. Citizen Sedillot the younger ſays, he has uſed it with great ſucceſs in frictions, and even internally, in rheumatic pains and affections.

No other combination of the acetic acid is yet known or employed in the arts.

Article VI.

Of the Panary and Colouring Fermentations.

1. IN ſpeaking of the diſtinctions of the different ſpecies of fermentation, I have aſſerted, that the fermentation, which I call *colouring*, is a mean between the acid and putrid fermentations, and that it was neceſſary to ſtudy it along with theſe: I here add the panary fermentation, becauſe it would be of little uſe to make it the ſubject of a particular article, and becauſe it equally holds a mean between the putrid and the acid. Beſides, though we ſee plainly, that both theſe ſpontaneous movements are really placed between theſe two fermentations, they are yet too little known, too little ſtudied, to be treated ſeparately, and to deſerve each a diſtinct article.

2. It requires but a ſimple and eaſy obſervation of dough of wheaten flour, expoſed to a temperature from fifteen to eighteen degrees, after being mixed with a certain proportion of yeaſt or paſte already fermented, to ſatisfy ourſelves that it experiences in fact a real fermentation. This dough riſes, ſwells, increaſes in bulk, dilutes internally, ſeparates in ſome points, and becomes filled with cavities or eyes, manifeſtly produced by the extrication of an elaſtic fluid.

At the ſame time it is obſerved to grow warm, it changes its colour, it does not retain its viſcous and adheſive conſiſtence; it acquires a ſmell ſomewhat pungent, and a taſte altogether different from the kind of inſipidity which it poſſeſſed before this movement. In theſe ſigns we cannot eaſily avoid diſcovering a true fermentation.

3. Attempts have been made to determine in what this fermentative motion of dough conſiſts; and to ſhow that it is not a particular fermentation, but merely the three fermentations ariſing ſimultaneouſly and reciprocally, confining the effects of each other to their commencement. According to this opinion, the feculent matter of the flour tends to grow ſour, while the ſaccharine mucous ſubſtance become viſcid, and the gluten putrifies. From theſe three movements coinciding, and mutually reſtricting each other, proceeds the mixed fermentation, which gives riſe to leavened dough, and produces light, delicate bread, agreeable to the taſte, and eaſy of digeſtion.

4. But this mode of viewing the ſubject is not yet ſupported by any ſubſtantial proofs. There is not enough ſaccharine matter in flour, and what is in it is not ſufficiently free, to produce the ſlighteſt movement of vinous fermentation: the fecula is neither ſufficiently at liberty, nor ſufficiently heated, to paſs into the ſtate of acetification in the ſhort ſpace during which the dough is riſing. We have nothing

left therefore but the glutinous matter, which is more abundant, more diluted, more raiſed by the water it has abſorbed; much more diſpoſed than the other component parts of the flour to undergo an inteſtine movement, which divides, ſeparates, and rarefies the maſs; which parts it ſo eaſily into flakes by its ſimple diſpoſition; which fills it, and forms the cavities ſo well known in bread duly riſen, and properly baked; which tends ſpeedily to decompoſe it completely, almoſt in the manner of animal ſubſtances. Though it is certain that it paſſes through an acid ſtage, when it is ſuffered to go beyond the ſimple riſing, which bread ought to have, it is equally ſo, that it likewiſe tends readily to putrify.

5. Thus without having recourſe to the ſimultaneouſneſs of three fermentations, we may admit one in the gluten of the flour, which fermentation is neither an acetification, nor a formation of wine, nor a putrefaction, but rather a commencement of putrid decompoſition, which only divides the maſs, diminiſhes, nay deſtroys its viſcoſity, extricates from it ſome bubbles of elaſtic fluids, modifies its taſte and ſmell; in a word, changes its properties in a very remarkable manner. Unqueſtionably it is not a fermentation completed, for then it would be a putrefaction: it is but a firſt ſtage of fermentation, which art checks, after having excited it, after having brought it to ſuch a point, as to give the dough that degree of attenuation

and lightneſs, which was requiſite to make good bread; for which reaſon the name of *panary fermentation* has been given it: it is far from being terminated; it has ſcarcely begun to act on the dough, and this has ſcarcely begun to riſe, when its progreſs is ſtopped by the baking, to which the maſs is ſubjected, in order to give it the taſte and deſirable properties of bread.

6. It is the ſame with the colouring fermentation, which is only carried a little further in the proceſſes of art, than that which dough for bread is made to undergo. Like this, too, it is only a real decompoſition more or leſs advanced toward putrefaction, a commencement of reſolution, which tends to deſtroy the vegetable matter completely. There is no perſon who has not obſerved, that, in the courſe of this putrid decompoſition, the vegetable ſubſtances that undergo it, aſſume in general a more or leſs decided colour. Thus fruits grow darker and brown, muſhrooms become black, mucilages change yellow and red; leaves immerſed in water ſeem at firſt to acquire a deeper green, and afterward aſſume a brownneſs which approaches to black. Thus the whiteſt vegetable ſalts, the tartrites and acetites, exhibit in their tranſparent ſolutions, yellow, brown, and blackiſh clouds or flakes, the mucous products of their ſlow alteration, which at length depoſit carbonaceous particles.

7. This conſiderably accurate, though very general notion, ought to be applied to what paſſes in

the preparation of ſeveral colouring matters derived from vegetable ſubſtances, which are fermented in the preparation of weld or woad, and of indigo. This phenomenon is pretty accurately proved: the fine blue colouration, the formation of the moſt beautiful, moſt laſting, and moſt valuable colour, that the art of dyeing poſſeſſes, is the produce of a real fermentation: and ſince the plant alone immerſed in water undergoes, in order to aſſume this tint, an inteſtine motion of which there are indubitable ſigns in the increaſe of volume and temperature, the riſing of a ſcum, and a conſiderable noiſe, and the rather copious extrication of an elaſtic fluid mixed with carbonic acid and carbonated hidrogen gas; we cannot avoid acknowledging this fermentation to be the true ſource of the colouring matter formed, ſince this does not appear without unequivocal ſigns of the fermentation.

8. But is it a fact, as it has appeared to ſome modern writers, that this colouration is a particular fermentation, that it deſerves to be carefully diſtinguiſhed from all others, and even expreſſed by a ſpecial name, as I have done in this article, to ſtrike the attention of all who would ſtudy vegetable chemiſtry with care? I do not think, that in the preſent ſtate of our knowledge we can embrace ſuch an opinion. No doubt, from the peculiar product obtained, which is not leſs remarkable than uſeful, we may adopt the term of colouring fermentation,

if we attach only this idea to it; but we ought not by this to underſtand, that it is a movement different from all others with which we are acquainted: we ſhould conceive it ſolely to indicate the peculiarity of the product.

9. The panary and colouring fermentations then are truly and eſſentially nothing but commencements of ſpontaneous decompoſition, which would quickly terminate in the putrefaction and complete diſſolution of the vegetable matters, if they were not ſtopped at a certain point, by ſubjecting the product of the former to that baking which converts it into bread; and by removing the divided and blue fecula of the other out of the liquor, in which it is proceeding toward putrefaction, and to dry it quickly. In the former, the dough is on the verge of acidity, when it is put into the oven: in the latter, a conſiderable quantity of carbonic acid and of ammonia is already formed at the expenſe of the plant, and if the production of either of theſe were to continue, a complete diſſolution of the vegetable would be the conſequence; but being ſtopped in due time, this decompoſition exhibits a matter already very carbonaceous, of which carbon conſtitutes the principle in exceſs, and renders its durability as a colouring ſubſtance ſo great, and its alteration ſo difficult.

ARTICLE VII.

Of the Putrid Fermentation.

1. PUTREFACTION is the laſt kind of fermentation I have diſtinguiſhed, and it is in fact that which terminates all the others, and effects the complete decompoſition of vegetables. No part of plants is exempt from this movement, and yet we may keep almoſt all free from it, by depriving them of water, the contact of air and heat. Some ancient chemiſts, Becher in particular, had eſtabliſhed a ſort of compariſon between putrefaction and combuſtion; and this idea, though it was difficult to prove it properly in remote times, was founded on an obſervation well made, and has been confirmed in our days.

2. For putrefaction to take place in vegetables many circumſtances are neceſſary. Their texture muſt be relaxed by water: all dry vegetable matters keep without alteration; on the contrary, all that are ſufficiently moiſtened rot. This happens to the hardeſt woods, the drieſt cords, the tougheſt ſtalks. The contact of air contributes greatly to produce and keep up this movement: we have a great number of facts of flowers and fruits being preſerved freſh and found in a vacuum, or in places well cloſed and ſecured

from the contact of air. A high temperature is not neceſſary to keep up vegetable putrefaction: ten or fifteen degrees are ſufficient, though a greater heat is not detrimental, but accelerates it; yet it muſt not be ſo great as to produce that dryneſs which is a preſervative from it. Exſiccation in an oven is the moſt antiſeptic proceſs known for all vegetable ſubſtances whatever. Quantities of vegetables heaped together, but not compreſſed, ſingularly favour this ſpontaneous analyſis.

3. All the conditions requiſite to putrefaction being united, this decompoſition announces itſelf by a change of colour and conſiſtency in the parts of plants; their texture relaxes and ſoftens; their laminæ, their fibres ſeparate and riſe up; their ſoft and fluid parts ſwell, and become covered with ſcum: elaſtic fluids diſtend them, traverſe them, and eſcape from them: their temperature increaſes, and ſometimes even ſo as to produce conflagration. The gaſes evolved, which are accompanied with a ſmell at firſt but little diſagreeable, afterward muſty or mouldy, then faint, fetid, ſlightly ammoniacal, are compounds of carbonated hidrogen gas, carbonic acid gas, and azote gas. Theſe phenomena diminiſh and grow weaker by degrees, after having continued a longer or ſhorter time, according to the conſiſtency of the vegetable, which loſes much of its ſubſtance in matter that evaporates, and leaves only a reſiduum more or leſs abundant, of a blackiſh colour, and containing

taining the moſt fixed of the materials that entered into its compoſition; namely, the earths, the acids that ſaturated them, and part of the carbon which gave it conſiſtency.

4. In theſe conditions, and in theſe phenomena, as well as in the products of the putrid fermentation of vegetables, we manifeſtly perceive the influence of the numerous attractions, which the materials that enter into the compoſition of their texture exerciſe on one another. The hidrogen in particular unites with the oxigen, and flies off as water; or is evolved as gas, carrying with it a portion of the carbon; while a third portion of this principle unites with the azote in plants that contain it, and forms ammonia; and a fourth and laſt part ſtill remains in the reſiduum, which it colours, and to which it ſtill imparts ſmell. The carbon unites in part with the hidrogen evolved; in part with the oxigen, which burns it, and carries it off as an acid; and a part remains in the reſiduum. The oxigen ſeparates itſelf from the plant with each of theſe two principles, with which it unites to make binary combinations.

5. Among the fixed reſults, the reſidues afforded by the putrid decompoſition of vegetables, we muſt particularly diſtinguiſh as uſeful objects, hemp, and other filamentous plants ſteeped, rotten wood, dung, and mould.

SECTION I.

Of the ſteeping of Hemp, Flax, Stipa Tenaciſſima, Spaniſh Broom, &c.

6. THE effect of the ſucceſſive action of water and air on the agglutinated and united fibres of the ſemiligneous ſtalks of filamentous plants, particularly of hemp, flax, the ſtipa tenaciſſima, and Spaniſh broom, when they are kept immerſed alternately in them, are well known: this operation is called rotting, and the places in which it is performed are termed ſteeping pits. Theſe plants are ſteeped for ſome days at the ſides of brooks, rivulets, ſome ponds, and even in the midſt of the water, being kept down with ſtones. The mucous and extractive gluten, which kept the fibres adherent, is diſſolved and decompoſed; the bark is readily detached from the interior woody texture; the cortical layers and their filaments are eaſily ſeparated.

7. Experience proves that running water is far preferable to ſtagnant, though prejudice has impreſſed a contrary opinion on many country people. Boiling in water ſlightly impregnated with alkali may ſupply the place of ſteeping, which, as it is moſt commonly practiſed, is ac-

companied with an inſupportable ſtench, and a real putrid decompoſition. It is from this laſt well known fact that I conſider hemp, and all other vegetable ſtalks in general that have undergone this proceſs of ſteeping, as a ſort of fibrous ſkeletons, freed by a putrid alteration from every thing that ſurrounded them. This decompoſition is ſtopped in due time, otherwiſe it would attack the fibrous texture itſelf, if it were allowed to continue, and deſtroy the tenacity of the filaments, as happens when the plant is ſteeped too long.

8. With theſe flexible and ſolid fibres are fabricated thoſe delicate and light cloths unknown to the ancients, of which poliſhed nations make the garments they wear next their ſkin. Linen we know has conſiderable ſtrength and durability. Yet by tearing and grinding it, after macerating it in water and ſuffering it to become half rotten, is made that pulp of ingenious invention, which, being diluted and ſuſpended in hot water, ſubſides in a thin layer on very fine ſieves dipped into the fluid, ſo as to form by precipitation thoſe ſheets of paper, which are ſet to dry, and covered with a vegetable or animal glue, that it may be afterward written upon without the ink ſinking into it.

SECTION II.

Of rotten Wood.

9. DEAD wood, altered upon the ground in different manners, and known by the name of *rotten wood,* is one of the moſt ſingular reſults of the putrid decompoſition of vegetables. The foot ſtalks of the leaves, the woody peduncles of flowers and fruits, ſlender twigs, the light ſtalks of ſhrubby plants or dried herbs, which have acquired a woody nature by deſiccation, corrupt, change, and are decompoſed; when lying on the ground and heaped together with leaves upon moſs, in hollows where water collects, more or leſs covered or penetrated by this fluid, and at the ſame time expoſed to the contact of air, we ſee them grow brown, blacken, ſplit, loſe their cortical layers in little ſcales or filaments, and exhibit beneath a yellowiſh, browniſh, or white flabby texture, without conſiſtency, of a mouldy ſmell, and in a ſtate of decompoſition which is called rotten.

10. We ſee pieces of ſolid timber, whole beams or planks, coming to this ſtate in the period of a few years, when they are expoſed to damp air, or in low places, where the water does not naturally evaporate. Thus the wood of fences, particularly in foreſts and courts that

have little circulation of air; beams and planks in cellars; floors and partitions in underground apartments, where the air is but little renewed, and remains conſtantly loaded with moiſture; become ſoft, crack, emit a mouldy ſmell, loſe their ſolidity, and at laſt ſeparate into white, pliant leaves and filaments, or into powder in dry weather.

11. Though all the phenomena that ſucceed each other and take place in this ſpontaneous deſtruction of wood have not yet been deſcribed, or perhaps obſerved with ſufficient care, at leaſt ſome have been noticed and mentioned, which it is neceſſary to record here. For inſtance, we know that the wood is phoſphoric, or ſo ſtrongly luminous, during the courſe of this ſlow putrefaction, and almoſt to the end of it, as to exhibit ſingular ſpectacles in the fields and woods. We know, that it conſtantly emits ſuch a ſmell, as is found in the claſs of agarics and ſpunks, the production of which ſeems frequently to be the conſequence of this putrefaction: we know that the mucous, extractive, feculent, oleaginous matters, which form a part of the compoſition of vegetables, are gradually deſtroyed, and eſcape from the ligneous ſubſtance during this decompoſition; and that they are found no more, or at leaſt are found in a ſtate much altered, yet but little aſcertained, and deſerving further examination.

12. When we examine the laſt reſiduum of theſe rotten woods, we remark that they have

loſt, beſides their ſolidity and their conſiſtence, the greater part of their primitive matter, weight, and ligneous property. Their combuſtibility is ſingularly diminiſhed: they burn feebly and rapidly; they give out little heat; they leave little cinder, but this cinder is ſtrongly ſaline, and many chemiſts have obſerved, that among the ſalts obtained from it, ſulphate of ſoda is conſtantly found in greater quantity than it is uſual to procure it from vegetable ſubſtances. Theſe firſt facts reſpecting the nature of rotten woods, ſufficiently ſhow, how important it may prove to vegetable phyſics, carefully to obſerve and attend to every thing that concerns the ſpontaneous alterations, to which they are liable.

SECTION III.

Of Dung.

13. THOUGH at firſt view there appears to be nothing in the ſlow decompoſition of the ſtems of herbaceous plants, and the ſtalks of graſſes, that differs eſſentially from that of other ſolid vegetable matters: yet the ſort of phenomenon they then undergo, and the product they furniſh under the name of *dung*, have a claim on our attention for a few moments, on account of their important uſe in agriculture. By the term dung, however, I do not here underſtand with the

generality of farmers that diverſified heap, that chaos of animal and vegetable ſubſtances, various in their nature, that filth of every kind, that is heaped on the ſtraw which has ſerved as litter to animals, and which, particularly impregnated with their liquid and ſolid excrements, afterward furniſhes land with a very nutritious manure: in this point of view it will be treated of in another place.

14. At preſent I conſider only the pure remains of the culms or herbaceous ſtalks of all plants, which, after having been heaped together and moiſtened in ſuch a manner as to be ſurrounded and even fermented by the air, grow hot, become coloured, ſeparate into pieces, and emit a fetid ſmell, an aqueous vapour impregnated with carbonated hidrogen gas, and ſometimes even ammonia: which grow ſoft, and partly diſſolve into a brown ſtrong-ſcented fluid, very uſeful to vegetation, and depoſiting charcoal by a ſlow precipitation: and of which another part is reduced into a blackiſh friable ſubſtance, which ultimately becomes pulverulent, and is confounded with the earth, to which it is gradually reduced after paſſing through the ſtate of mould, which will preſently be examined.

15. During this decompoſition, which renders theſe remains of vegetables ſo fit for meliorating, enriching, manuring, or forming the ſoils in which they are mixed by the help of the plough; the principles that conſtitute theſe vegetable

compounds, re-acting on one another, are united by the progreſs of a ſlow fermentation in an order different from that in which they had been combined by vegetation, partly eſcape in the form of vapour, and partly diſſolve in a thick liquor called *dunghill water*. Some portions of theſe remains preſerve a ſolid form, notwithſtanding they loſe the greater part of their texture and organization. All theſe elements, combined more ſimply than they were in the compounds of which they made a part, tend gradually to reſtore to the earth and air what they borrowed from them during their vital movement; and it is by the effect of this decompoſition, that dung is of ſo much uſe as manure, and for the ſupport of vegetation, as will be ſaid hereafter.

SECTION IV.

Of Mould.

16. The laſt ſtage of the ſlow and manifeſtly putrid decompoſition of herbaceous ſtalks, the end of the dung which in this ſtate is ſaid to be exhauſted, is its reduction into mould. By this term is implied the pulverulent, blackiſh, fat reſiduum, which dung leaves after its total decompoſition; called in French *terreau*; becauſe it reſembles the ſtate and form of an earth,

and becauſe it adds to the terreſtrial globe ſtrata, that cover its ſurface, apparently increaſing the extent and depth of it. In ſome points of view it may be conſidered as the ſkeleton of herbaceous ſtalks: but we ſhould be wrong to ſuppoſe as formerly, that it conſiſts ſolely of the fixed matters, that enter into the compoſition of theſe ſtalks.

17. In this laſt reſpect the name of *vegetable earth*, which has been given it, can expreſs only its external appearance or phyſical properties. It muſt not be confounded with an earth properly ſo called, ſince earthy ſubſtances are frequently the leaſt portion of the matters that conſtitute mould. The firſt analyſis made of it a few years ago by Citizens Giobert and Haſſenfratz, ſhowed the preſence of oleaginous matters, extractive ſubſtances, and charcoal ſtill containing much hidrogen. Accordingly, when ſubjected to diſtillation, mould yields odorant elaſtic fluids and liquid products. When it is boiled in water, it colours it, and communicates to it taſte and ſmell. When it is heated in contact with air, it takes fire, and ſometimes inflames with conſiderable activity: but indeed it muſt be obſerved, that if mould be carefully waſhed, organized fragments, ſtalks, &c. are almoſt always found in it. There have been likewiſe found in freſh mould, acetites and benzoates of pot-aſh, lime, and ammonia, ſulphate and muriate of pot-aſh, and a kind of ſaponaceous ſubſtance already mentioned by Bergman.

18. Among the fixed materials we find a remarkable quantity of carbon in a very divided ſtate, carbonate of lime, phoſphate of lime, ſilex, alumine, magneſia, iron, and manganeſe. Sometimes the ſilex in it is very abundant: for it may readily be conceived, that, according to the nature of the plants from which it proceeds, the mould muſt differ in the proportion of its fixed reſiduum, and in its principles. It is aſſerted, that ſmall quartz or rock cryſtals, very regular and very tranſparent, are conſtantly found in it: and there is nothing improbable in this, ſince we know ſo many inſtances of the preſence and ſolution of ſilex in the organs of plants and animals.

19. One of the moſt recent diſcoveries concerning mould and vegetable earth, which at the ſame time moſt forcibly proves the combuſtible and very compound nature of this putrid reſiduum of plants, is that which indicates in this ſubſtance a very ſtrong power of abſorbing atmoſpheric oxigen with much promptneſs, and reducing air to its azote gas. Dr. Ingenhouſz, who made this diſcovery, and Mr. Humboldt, who has confirmed and extended it by ſucceſſive reſearches, have both thought this abſorption ſo ſtriking, that mould might be employed for eudiometrical experiments. We ſhall ſee preſently, that this very remarkable property is of ſuch a nature, as to throw light on vegetation, manures, and ſoils.

20. If we reflect ever ſo little on the concatenation and economy of natural phenomena, we ſhall perceive, that this formation of mould, which is a neceſſary conſequence of the ſucceſſive decay of vegetables, is the grand and ſimple means employed by nature, to furniſh a continual ſupply of food for freſh vegetation; that ſuch is in fact the character of the ſoil of all woody places, that it is one of the ſources of its inexhauſtible fertility, and that thus it makes the ſame primitive matter ſerve continually to develope all the germs that grow, and ſupport their life. It may be ſuppoſed, that art muſt have availed itſelf of this grand obſervation, to imitate the fertility of nature, to increaſe the productions which human induſtry demands, and to prevent lands from being ſpeedily exhauſted, as they would be without this perpetual aſſiſtance.

ARTICLE VIII.

Of the ſlow Decompoſition, and various Changes, which Vegetables undergo in the Boſom of the Earth.

1. VEGETABLES and their parts have likewiſe natural modes of deſtruction, different from thoſe which have hitherto been deſcribed, and which are not real fermentations. When they

are buried under ground, or carried together in a maſs into the ſea; which frequently happens in conſequence of earth-quakes, openings of the ground, the ſinking of cliffs, the fall of rocks or large maſſes of ſnow from the mountains, inundations, torrents, currents, &c.; they are excluded from the contact of air, and moſt frequently from the temperature neceſſary to produce fermentative movements, ſo that they undergo nothing reſembling the vinous, acetous, or even putrid fermentation. Penetrated by aqueous molecules which never quit them, or which, inſinuating themſelves into them from time to time, carry with them ſaline, acid, earthy, metallic, and other particles; or waſhed and agitated continually by maſſes of ſalt water impregnated beſides by a number of matters in a ſtate of ſolution, particularly by various animal productions: they find in the courſe of their very deſtruction the cauſe of new effects and modifications, which change their nature, or which, while they retain a part of their former compoſition, give it a very different turn or faſhion from what it before preſented.

2. When we conſider the ſeveral known changes, different from thoſe produced by fermentation, of which vegetables are ſuſceptible in the very midſt of deſtruction, and by its more or leſs ſlow effect, without our being able to attribute or compare them to their true putrefaction, we find four kinds of products, equally formed by ſubterranean alterations, and equally

deſerving to be ſtudied in the ſeries of chemical operations, which nature performs in the large way. In order to appreciate their mutual reports, their differences, their production, and their uſes, I ſhall here deſcribe them in ſucceſſion under the heads of

1ſt, foſſil woods;
2d, turf or peat;
3d, bitumens;
4th, petrified vegetables.

SECTION I.

Of Foſſil Wood.

3. IN the interior part of the earth, and particularly along the banks of moſt large rivers, we frequently find wood buried ten or fifteen metres deep, ſtill very diſtinguiſhable, not only by the form, texture, and conſiſtence, but by the great quantity and ſtate of the trunks and branches lying together in larger or ſmaller heaps. We ſeldom dig near the banks of running waters, or beneath their beds, without diſcovering ſuch wood, ſometimes in ſo great quantity, that we cannot avoid perceiving whole trees, and even parts of foreſts, ſwallowed up by grand cataſtrophes, ſuch as we ſometimes ſee, and which occur ſtill more frequently near thoſe great rivers of vaſt uninhabited continents, the ſoil

of which is every where covered and loaded with the produce of an ancient vegetation, that has continued through a long ſeries of ages.

4. Theſe foſſil woods are commonly of a brown or almoſt black colour, and of a ſoft and tender conſiſtence, as long as they remain buried. They readily harden, and even become very hard, when they continue ſometime expoſed to the air, ſtill preſerving a dark colour, and acquiring by deſiccation a much finer and cloſer texture than they originally poſſeſſed. Sometimes they are employed with great advantage for certain purpoſes of building, particularly in places neceſſarily more or leſs expoſed to the contact of damp air, as underground apartments, &c. becauſe they are no longer capable of being affected by the humidity of the atmoſphere. Foſſil wood is ſtill extremely combuſtible: it burns with little flame, but gives out great heat: it affords a denſe and heavy charcoal if it be extinguiſhed when half burned. The oil it yields on diſtillation is fetid and nearly ſolid.

5. In all theſe properties we diſcern a ligneous ſubſtance, which has undergone ſome changes: it is not perfectly of the ſame nature as before. The ſtrata of wood penetrated with water have loſt a portion of the mucous, extractive, ſoluble matter, which they contained. They have been reduced more or leſs to the ſtate of a pure woody ſkeleton: even a portion of the external ſubſtance of the ligneous fibres has been decompoſed, and reduced to the form and colour of

charcoal: a part of their hidrogen has been taken from them. When the water which impregnates them and keeps them ſeparate is diſſipated, theſe layers contract and preſs cloſely upon each other: hence, reſults that hardneſs, that compact texture, and that ſhining ſurface, which they acquire when cut and poliſhed; and hence, the little flame they emit, when burned in a fire-place. In fine, we perceive that foſſil wood, though ſtill ligneous, is in its progreſs to deſtruction, and that a longer ſtay in the earth would in the end deſtroy it completely, by diminiſhing more and more all the properties of vegetable matter it poſſeſſes. Accordingly, we ſometimes find it friable, no longer capable of becoming dry and ſolid, but crumbling and reducible to a ſort of mould by rubbing.

Section II.

Of Turf or Peat.

6. THE explanation juſt given of the effects produced on wood by moiſt earth, and water filtering through it, which thus reduce it to its coally ſkeleton, is equally applicable to plants buried in the earth. There are likewiſe many low grounds, which, nearly on a level with ſmall rivers, and ſometimes even below it, are alternately covered with earth and left by their

waters, or admit them in ſuch a manner, as to be continually fermented by them. Theſe grounds producing an enormous quantity of plants crowded together, inceſſantly growing, and annually accumulating layer upon layer, their ſoil becomes loaded to a greater or leſs depth with remains of vegetables, or herbaceous ſtalks, interwoven with each other in all directions, of a black and coally colour, and of a diſagreeable or even fetid ſmell, which indicate a conſiderably advanced ſtage of vegetable decompoſition.

7. Theſe remains, ſtill ſolid and combuſtible, are known by the name of *turf* or *peat*, and the places from which they are taken are called *bogs*, or *turbaries*. Though peat conſiſts of coherent maſſes, belonging to a much larger maſs of one ſingle piece of a ſubterranean depoſit, yet by ſeparating the filaments which compoſe their texture, we may diſtinguiſh ſeveral of the plants, which have contributed to their formation. They are ſeparable into long, ſoft, brown, or black ſtalks, ſometimes indeed of a bluiſh or violet colour, which have loſt the natural conſiſtence of the plants to which they belonged, and are manifeſtly altered in their texture as well as in their nature.

8. When turf is heated in an apparatus for diſtillation, we obtain from it a yellow or reddiſh fetid water, an extremely ſtinking oil, carbonate of ammonia, and carbonated hidrogen gas of a very diſagreeable ſmell. The reſiduum is a

coal, frequently pyrophoric, from which ſome ſalts may be extracted after incineration, particularly muriates and ſulphates of ſoda and potaſh, mixed with phoſphate of lime, calcareous ſulphate, and oxides of iron and manganeſe. Every perſon knows the manner in which turf burns in fire-places and furnaces, the ill ſmell it emits, and the reddiſh ferruginous aſhes it leaves. Attempts have been made with ſome ſucceſs to diveſt it of theſe inconveniencies, by half burning it in cloſe veſſels ſo as to char it like wood. This proceſs has certainly its advantage. It muſt be mentioned however, that this charcoal is inferior to that commonly made from wood; and that it is liable to take fire from the combined action of air and water, ſo that it ought to be kept for uſe in cloſe places well ſecured. I ſaw a yard in Paris filled with this charcoal, induſtriouſly and even ſkilfully manufactured, occupying a vaſt ſpace open to the air. After a few days rain, to which it was conſtantly expoſed, a copious white ſmoke aroſe from it, which was ſoon converted into a flame, and entirely conſumed the charcoal, at the ſame time threatening every inſtant a more general conflagration, by communicating to other combuſtible ſubſtances near.

9. Turf therefore is in reality the reſiduum of plants or herbs half decompoſed, half burned, reduced almoſt to the ſtate of charcoal, analogous in its nature to foſſil wood, which is equally carbonaceous. It is uſed as fuel, where there is

no other: it may be very uſeful in forges: its aſhes are employed as manure. By lixiviation, ſalts of uſe in the arts may be obtained from it. There are ſome turbaries which are found to contain likewiſe ſulphuret of iron, or pyrites. This compound, ſo combuſtible in moiſt air, heats them when they are expoſed to it, and even occaſions them to take fire. Some of them, ſuch as thoſe in the environs of Beauvais, are even capable of furniſhing by lixiviation ſulphate of iron, which is formed in them by expoſure to the air. There is no doubt, that moſt turfs may be employed for obtaining from them by diſtillation an oil analogous to tar, as Becher propoſed in 1683.

SECTION III.

Of Bitumens.

10. Bitumens, are produced like foſſil wood and turf from vegetables or parts of vegetables, heaped up and buried in the waters and in the earth, but differ from both of them in being combuſtible ſubſtances without any organic texture or appearance in the greater part of their maſſes, which are homogeneous, brittle, and as it were vitreous in their conſiſtence, when ſolid; in furniſhing, all without exception, acid or ammonia, when diſtilled, and leaving a coal di-

vided in the form of fibres or laminæ. It may eaſily be known however, that they have belonged to the vegetable kingdom, by their oily nature, by the carbon they contain, and likewiſe by their vegetable origin being manifeſt in them, either by the ſeeds, leaves, or ſtalks of which they exhibit impreſſions, or by the ligneous nature which they frequently ſhow at one of their extremities.

11. Formerly they were confounded with ſulphur, bearing the ſame appellations, as they were termed a *mineral ſulphur*, while ſulphur itſelf was ſometimes called *bitumen*, or *bituminous juice*. They were likewiſe conſidered for a time as mineral productions, as terrene oils; and their vegetable origin was not then underſtood. At preſent there is no longer any difficulty in diſtinguiſhing them from *anthracite*, a ſpecies of carbonaceous matter mixed with one-third of its weight of ſilex and a little iron, which exiſts in the primitive mountains, and affords no oil; while bitumens, which are found only in ſtrata of the ſecond or third order, contain, or yield when acted on by fire, more or leſs oil. It is evident that bituminous productions cannot be conſidered as belonging to the claſs of minerals; or at leaſt of being in ſome reſpects related to it, merely becauſe they are found in the earth among foſſils.

12. Four ſpecies of bituminous matters ſhould be diſtinguiſhed: *bitumen*, properly ſo called, *coal*, *jet*, and *amber*. Their ſpecific differ-

ences are very well marked by the following characters:

Bitumen is fluid or ſoft: it yields no ammonia on diſtillation; it leaves very little coally reſiduum.

Coal affords much ammonia, and leaves much coally reſiduum after diſtillation, much earthy matter after incineration.

Jet is ſuſceptible of a fine poliſh: when diſtilled, it gives out a liquid acid.

Amber is tranſparent: it furniſhes a concrete acid by ſublimation.

We muſt examine the properties, origin, nature, and uſe of each ſpecies in particular.

A. *Bitumen.*

13. At preſent, the name of *bitumen* is confined to oleaginous foſſil ſubſtances, which give out no ammonia when acted on by fire, which emit no fetid ſmell when burned, and which after they are burned leave little earthy reſiduum.

14. There are two principal varities of bitumen, one more or leſs fluid from the lightneſs of naphtha to the conſiſtency of pitch. This variety is called *naphtha*, *petroleum*, or *piſſaſphaltum*, according to its liquidity. The ſecond, which is ſolid, or nearly ſo, is called *aſphaltum*.

FIRST VARIETY.

Liquid Bitumen; Petroleum.

15. THE name of *petroleum*, or *rock-oil*, has been given to a fluid bituminous ſubſtance, which flows between ſtones, on rocks, or in different parts of the ſurface of the earth. This oil differs in lightneſs, ſmell, conſiſtence, and inflammability. Authors have diſtinguiſhed a pretty conſiderable number of ſub-varieties of it. They have given the name of *naphtha* to the lighteſt, moſt tranſparent, and moſt inflammable petroleum; that of *petroleum*, properly ſo called, to a liquid bitumen of a deep brown colour; and laſtly, that of *mineral pitch* to a black, thick bitumen of little fluidity, tenacious, and ſticking to the fingers. The following are the ſub-varieties deſcribed by Wallerius and ſeveral other naturaliſts.

VARIETIES.

1. WHITE naphtha.
2. Red naphtha.
3. Green or dark naphtha.
4. Petroleum mixed with earth.
5. Petroleum exuding from ſtones.
6. Petroleum floating on water.
7. Mineral pitch, or maltha.

8. Piſſaſphaltum. This is of a mean conſiſtence between that of common petroleum, and that of aſphaltum, or Jew's pitch.

16. The different naphthas are found in Italy, in the neighbourhood of Modena, and at Monte Ciaro, twelve leagues from Placenza. Kempfer ſays, in his *Amœnitates exoticæ*, that a great quantity is collected in ſeveral parts of Perſia; and that a place in India, where it burns, is ſaid to contain the devil, whom God has ſhut up there. Petroleum flows in Sicily, and in ſeveral parts of Italy; in France at the village of Gabian, in Languedoc, and in Alſace; at Neufchâtel, in Switzerland; in Scotland; and in other places. Piſſaſphaltum and mineral pitch were formerly obtained from Babylon, in conſtructing the walls of which place they were employed; from Raguſa, in Greece; and from the marſh of Samoſata, the capital of Commagene, in Syria. At preſent they are procured from the principality of Neufchâtel, and from Vallengin, Puits, Pege, a league from Clermont-Ferrand, in the department of Puy de Dome, and ſeveral other places.

17. With regard to the different ſub-varieties mentioned, it is to be obſerved, that they all appear to have the ſame origin, and that they differ from one another only by ſome particular modification. Moſt naturaliſts and chemiſts attribute the formation of petroleums to the decompoſition of ſolid bitumens, by the action

of the ſubterraneous fires. They obſerve, that naphtha appears to be the lighteſt oil, which the fire firſt diſengages; that what ſucceeds it, aſſuming colour and conſiſtency, forms the different ſorts of petroleums; and that the latter, by uniting with ſome earthy ſubſtances, or being altered by acids, acquire the characters of mineral pitch, or piſſaſphaltum. In ſupport of this opinion, they make a very exact compariſon of the phenomena exhibited by the diſtillation of amber, which in fact affords a ſort of naphtha, and a petroleum more or leſs brown, according to the degree of heat and time of the operation. Finally, they obſerve, that nature frequently preſents us with all the ſpecies of petroleum, from the lighteſt naphtha down to mineral pitch, in the ſame ſpot, as in the caſe of the fluid bitumens obtained from Monte Feſtino near Modena.

18. For the reſt, the chemical properties of petroleum have not yet been examined with ſufficient care. We only know, that naphtha is very volatile, and ſo combuſtible, that it catches fire if any thing burning be brought near it: it ſeems even to attract flame in conſequence of its volatility. From the brown petroleum we obtain an acid phlegm, and an oil, which at firſt reſembles naphtha, and which becomes coloured as the diſtillation advances. What remains in the retort is a thick matter like piſſaſphaltum, which may be rendered dry and brittle as aſphaltum, and reduced entirely to

the coally ſtate by a ſtronger fire. Alkalis have little action on petroleum: ſulphuric acid darkens its colour, and renders it thicker; nitric acid inflames it, as it does volatile oils: it eaſily diſſolves ſulphur: it is coloured by metallic oxides: it unites with amber, part of which it ſoftens and diſſolves by means of heat.

19. The different kinds of petroleums are employed for different purpoſes in the countries where they abound. Kempfer informs us, that in Perſia they are uſed to give light, and are burned in lamps by means of wicks. They may likewiſe be uſed to give heat. Lehman ſays, that for this purpoſe ſome naphtha is poured on a few handfuls of earth, and kindled with paper; when it immediately burns briſkly, but diffuſes a thick and very copious ſmoke, which adheres to every thing, and the ſmell of which is very diſagreeable. It is ſuppoſed too, that petroleum enters into the compoſition of the Greek fire. The thick petroleum is employed likewiſe for making a very ſolid and very durable mortar. By boiling piſſaſphaltum with water an oil is obtained from it, which is uſed for tarring ſhips. In India the flame produced by a burning petroleum is worſhipped, and the heat it emits is uſed for dreſſing victuals, and burning lime.

20. Laſtly, ſome phyſicians have ſucceſsfully employed petroleum in diſeaſes of the muſcles; in palſy, debility, &c. by rubbing or fumigating the ſkin with it. Van Helmont conſidered frictions

tions with petroleum as a very good remedy for frozen limbs, and recommended them as an excellent preſervative againſt the action of cold.

VARIETY II.

Solid Bitumen, or Aſphaltum.

21. Aſphaltum, or Jews pitch, called likewiſe *funeral gum, amber of Sodom, mountain pitch, balſam* of *mummies,* &c. is a black, heavy, ſolid, and ſomewhat ſhining bitumen. It breaks eaſily, and its fracture is vitreous. A thin ſlip of this bitumen appears red when held between the eye and the light. Aſphaltum has no ſmell when cold, but acquires a ſlight ſmell by rubbing. It is found on the waters of the lake Aſphaltites, or Dead Sea, in Judea, near which were anciently the cities of Sodom and Gomorrah. The people, incommoded by the ſmell which this bitumen diffuſes as it lies on the water, and encouraged by the profit they gain by it, collect it carefully. Lemery ſays, in his Dictionary of Drugs, that the aſphaltum exudes as a liquid pitch through the ground which is covered by the Dead Sea, and that riſing to the ſurface of the water, it is there condenſed by the heat of the ſun, and by the action of the ſalt, which that water contains in abundance. It is met with likewiſe on many lakes in China. Wherever piſſaſphaltum is found, the portion that is dried in the air becomes a ſpecies of aſphaltum,

phaltum, which may be uſed for the ſame purpoſes as that of the lake of Judea. What is found near Neufchâtel, in Switzerland, is thus employed.

22. Naturaliſts are divided in opinion reſpecting the origin of aſphaltum, as of all the bitumens. Some imagine it to be a mineral production, formed by an acid united with an unctuous matter in the bowels of the earth: others conſider it as a reſinous vegetable ſubſtance, buried in the earth, and altered by mineral acids. The moſt general and moſt probable opinion is, that its origin is the ſame with that of amber; and that it is formed by this laſt bitumen, which has undergone the action of a ſubterraneous fire. This opinion is founded on the circumſtance that amber, melted and deprived of a part of its oil and ſalt by the action of fire, becomes black, dry, brittle, and perfectly ſimilar to aſphaltum: but it can be confirmed only by a comparative analyſis of aſphaltum; and this reſiduum of amber and aſphaltum has not yet been examined with the accuracy neceſſary to aſcertain this analogy.

23. Aſphaltum, when expoſed to the fire, melts, ſwells up, and burns, emitting flame, and a thick ſmoke, the ſmell of which is ſtrong, acrid, and diſagreeable. By diſtillation we obtain from it an oil coloured like brown petroleum, and an acid water. By fuſion it mixes intimately with ſulphur, phoſphorus, ſeveral metallic oxides, and particularly fixed and vola-

tile oils, reſins, and gum-reſins. It is no way altered by alcohol, which does not touch the bitumens in general. The action of ether on theſe ſubſtances is a little more perceptible, though very ſlight.

24. The Arabs and Indians uſe aſphaltum inſtead of tar to coat ſhips. It is uſed in the compoſition of the black varniſhes of China, and in fire-works to burn on water. The Egyptians employed it for embalming dead bodies; but only for thoſe of the poor, who could not pay for more coſtly antiſeptics. Wallerius aſſerts, that ſome merchants prepared a ſort of aſphaltum with inſpiſſated pitch, or by melting pitch, and mixing it with a certain quantity of real aſphaltum: but this fraud may be detected by means of alcohol, which diſſolves the pitch intirely, but only acquires from the aſphaltum a pale yellow colour.

B. *Coal.*

25. COAL has received the names of *pit-coal, ſtone-coal, lithanthrax*, from its combuſtible property, and the uſe made of it in ſeveral countries. It is found in the earth, moſt commonly below ſtones of leſs or greater hardneſs, ſandſtones, and aluminous and pyritous ſchiſtus. Theſe laſt conſtantly exhibit the impreſſions of ſeveral vegetables of the family of ferns, moſt of which, according to the obſervation of Bernard de Juſſieu, are exotic. The bamboo and

banana have been diſtinguiſhed in the pit-coal of Alais. It lies more or leſs deep in the earth. It is always arranged in ſtrata, either horizontal or inclined, but more frequently the latter. The beds or ſtrata of which it conſiſts differ in thickneſs, conſiſtency, colour, ſpecific gravity, &c. Frequently over this bitumen are found beds of ſhells, impreſſions of fiſh, and foſſil madrepores, of greater or leſs extent, which has led ſome moderns to ſuppoſe, particularly Citizen Parmentier, that pit-coal has been formed in the ſea by the depoſition and alteration of the oily or fatty matter of marine animals. Moſt naturaliſts conſider it as the product of a reſiduum of wood buried and altered by the water and ſalts of the ſea. We frequently find above coal, plants and wood partly diſtinguiſhable, and partly converted into coally bitumen. Its formation appears to be owing to the decompoſition of an immenſe quantity of land and ſea-plants, and to the ſeparation of their oil, united with alumine and calcareous matter. We cannot deny that animal matters likewiſe enter into its compoſition.

26. Beds of coal are worked as mines, by ſinking pits and hollowing out rooms, the bitumen being got out with pick-axes, or a ſort of mattocks. The workmen who are employed in this are often expoſed to the danger of loſing their lives by the elaſtic fluids diſengaged from it. This kind of mephite is called *choke-damp*, *black-damp*, or *ſtyth*, by the colliers; it

extinguiſhes the lamps, and appears to be carbonic acid gas. In theſe mines too a very deleterious kind of carbonated hidrogen gas is evolved, which ſometimes produces dangerous exploſions.

27. Coal is very abundant in nature. It is found in England, Scotland, Ireland, Hainault, Liege, Sweden, Bohemia, Saxony, &c. Several departments of France furniſh a great deal, particularly thoſe which occupy what was formerly Burgundy, the Lyonneſe, Forez, Auvergne, Normandy, &c. Though the Engliſh greatly excel the French in the art of working coal, and employing it for the uſe of man; and though they have expended large ſums, and executed magnificent works for the purpoſe, ſuch as the ſubterranean canal of the Duke of Bridgewater, which is near five thouſand metres long; yet France poſſeſſes more wealth of this kind than England; and its induſtry, rouſed by neceſſity, will ſoon equal that of its neighbour and rival.

28. Coal has been diſtinguiſhed into *ſtone-coal* and *earth-coal*, according to its hardneſs or friability: but the manner in which it burns, and the phenomena it exhibits in combuſtion, afford much more important characters to diſcriminate its different varieties. In this point of view Wallerius diſtinguiſhes three: 1ſt, the *ſcaly-coal*, which remains black after being burned: 2d, the compact and foliaceous *coal*, which, after having been burned, afford a

ſpongy ſubſtance reſembling ſcoriæ: 3d, the *fibrous-coal*, like wood, which is reduced to aſhes by combuſtion.

29. Coal heated in contact with air, and ſome other ſubſtance in a ſtate of combuſtion, kindles with a ſlowneſs and difficulty proportionate to its gravity and compactneſs. Once kindled, it emits a ſtrong and laſting heat, and remains burning a long time before it is conſumed: it may even be extinguiſhed and employed ſeveral times over again. Its inflammable matter appears very denſe, and as it were fixed by ſome other incombuſtible ſubſtance, which retards its deſtruction. In burning it emits a ſtrong and peculiar ſmell, which however is by no means ſulphureous, when the coal is very pure, and contains no pyrites. The combuſtion of this bitumen appears very analogous to that of organic ſubſtances, as it is capable of being ſtopped, and divided into two periods. In fact, the oily combuſtible part, the moſt volatile the coal contains, is diſſipated in flame by the firſt action of the fire: and if a ſtop be put to the combuſtion, when all this principle is diſſipated, the bitumen retains only the moſt fixed and leaſt inflammable portion of its oil, reduced to a truly charred ſtate, and combined with an earthy baſe. By a proceſs of this kind, the Engliſh prepare their coke, which is nothing but coal deprived of its oily and fuſible part by the action of fire.

30. We may ſee clearly what paſſes in the action of fire upon coal, by heating this bitumen in cloſe veſſels, and in an apparatus for diſtillation. Thus we obtain from it an ammoniacal water, concrete carbonate of ammonia, and an oil, which grows darker coloured and heavier in proportion as the diſtillation advances. At the ſame time a great quantity of inflammable elaſtic fluid paſſes over, which is conſidered as an oil in a ſtate of vapour, but which is hidrogen gas mixed with azote gas, carbon in ſolution, and carbonic acid gas. What remains in the retort is a ſcorified coally ſubſtance ſtill capable of burning: it is the Engliſh coke. If we carefully obſerve the action of the fire on very pure coal, we ſhall perceive it evidently ſoftened, and ſeemingly undergoing a ſemi-fuſion: now as we may imagine this ſtate to be detrimental in the fuſion of ores, it is of eſſential importance to deprive the bitumen of this property. In this we may ſucceed by diveſting it of the principle, which occaſions it thus to ſoften, namely, of the oil which it contains in great abundance, and by reducing it to a ſtate ſimilar to that of charcoal made from vegetable ſubſtances. It is to be obſerved, that the pretty conſiderable quantity of ammonia furniſhed by coal favours the opinion of its animal origin: ſince, as will be ſeen in another place, the ſubſtances belonging to this claſs of compounds always yield ammonia when diſtilled. This ana-

lyſis is effected in the great in particular works erected in Scotland by Lord Dundonald. The oil, which is collected in reſervoirs cooled by the water of a river that paſſes underneath, is uſed as tar; the ammonia is employed for making ammoniacal muriate; and the reſiduum is very good coke. Citizen Faujas has imported this uſeful art into France; and the experiments, which he has made on a ſmall ſcale at the Muſeum of Natural Hiſtory, have ſucceeded extremely well: notwithſtanding this, however, no works have yet been erected for carrying on this manufacture. After the combuſtion of coal, its aſhes contain ſulphates of iron, magneſia, lime, alumine, or, if the combuſtion have been very rapid, the baſes of theſe ſalts.

31. Coal is a combuſtible every where uſeful, but particularly in countries where there is no wood. It is uſed for all domeſtic purpoſes; and there is no reaſon to fear the dangers which ſome have aſcribed to its uſe. The ſulphureous vapour, which it is ſuppoſed to emit during combuſtion, need not be dreaded, ſince the moſt accurate analyſis has proved to all chemiſts, that coal, when pure, contains not a particle of ſulphur. Hence, we ſee how falſe and deceitful are the pretenſions of thoſe ignorant men, who announce proceſſes for deſulphurating this bitumen. Another conſideration, which ought to induce us to derive all the advantage we can from coal, particularly in France, is, that as the working of mines conſumes enormous quantities

of charcoal, there is reaſon to apprehend we ſhall, ſome time or other, be in want of wood. It is particularly in works of this kind that we ought to endeavour to employ coal, as the Engliſh have long done: indeed its uſe begins to be eſtabliſhed in ſeveral ſuch works, of which the famous iron founderies at Creuſot, near Mount Cenis, and at Autum, afford great and uſeful examples.

32. Purified coal, falſely called *deſulphurated*, is nothing but that which is deprived of its oil by the action of fire. This ſort of charcoal burns without ſmoke, without growing ſoft, without any ſtrong ſmell; in a word, it is real coke; and on account of theſe properties, is preferred for burning in the fire-places of rooms.

One of the great inconveniences of coal, beſide the very abundant and thick ſmoke it emits, which blackens all the furniture in a room, is, that the very rapid and copious current of air it requires for its combuſtion, carries up and volatilizes part of its aſhes, which adhere to every thing around: but both theſe inconveniences may be remedied in great meaſure by conſtructing the fire-place in a proper manner; ſo that the whole of the current excited by the combuſtion may paſs up the chimney, without any part of it being returned into the room.

The great utility of this combuſtible in France will be found more particularly in manufactories of every kind; and its uſe will occaſion a very a very great ſaving of wood for the purpoſes of building and common fires.

C. *Jet.*

33. JET, the *gagates* of the Latins, the black amber of Pliny, the *pangitis* of Strabo, is black, hard, compact, vitreous in its fracture, and capable of acquiring a fine poliſh by friction, which renders it electric. It is deſtitute of ſmell, but becomes ſlightly fetid when heated. It ſoftens and ſwells up without melting completely: it burns and diffuſes a ſtrong ſmell during combuſtion.

34. We cannot miſtake its origin, when we examine it attentively in the places where nature offers it to our view. Naturaliſts were miſtaken in ſuppoſing that it was aſphaltum indurated by time. It is manifeſtly the product of a ſlow decompoſition of wood buried in the earth. In collections and cabinets we find pieces of wood converted into jet in one part, and yet evidently ligneous throughout the greater portion of their ſubſtance. At St. Jean-de-Cucule, near Montpellier, and at Niſmes, ſeveral trunks of trees, very diſtinguiſhable by their ſhape, have been found changed into jet. Citizen Chaptal mentions a ſhovel converted into jet throughout. The jet of Vachery, in the ci-devant Gevaudan, perceptibly exhibits the texture of walnut wood; and that of beech is ſeen in the jet of Boſrup, in Sileſia.

35. By diſtillation, we extract from it a little water and a brown oil, which is rectified by cohobation with argil. It yields leſs than fat coal. The ſmell it emits in burning, and which diſtinguiſh its products, without being fetid like that of coal, is more potent, more pungent, and more ſenſibly bituminous, or more analogous to that of amber, which will be mentioned preſently.

36. Jet is wrought for making trinkets and ornaments for mourning. Bracelets, buttons, necklaces, and ſnuff-boxes, are made of it at Wirtemberg and in France at Sainte-Colombe near Caſtelnaudary. A quarry of it too is wrought at Beleſtat, in the Pyrenees.

D. *Amber.*

37. Amber, or *yellow-amber*, as it is ſometimes called, is the moſt beautiful of all the bitumens in external appearance. It is in irregular pieces, of a yellow colour, ſometimes reddiſh or brown, tranſparent or opaque, formed of coats or layers, and is ſuſceptible of a very fine poliſh. When it is rubbed ſome time, it becomes electric, and capable of attracting ſtraws. By the ancients, who were acquainted with this property, it was called *electrum*, whence is derived our word *electricity*.

38. This bitumen is of a pretty hard conſiſtence, approaching to that of certain ſtones; which has induced ſome authors, particularly

Hartmann, a naturaliſt who lived near the concluſion of the ſeventeenth century, to rank it among the gems. It is friable, however, and brittle. The ancients too reckoned it in the number of precious minerals, and conſidered it as approaching the diamond: accordingly, their poets have given it a place in fable. Some of theſe feigned it to be the tears of the ſiſters of Meleager, changed into birds, and weeping for their brother: others the tears of the ſiſters of Phaeton, which were converted into amber as they fell into the waters of the Po.

39. When amber is powdered it emits a ſomewhat pleaſing ſmell. Within it are frequently found inſects very well preſerved, and very diſtinguiſhable; which proves that it has been fluid, and in this ſtate enveloped the ſubſtances we find in it. Amber is moſt frequently buried at a greater or leſs depth. It is found under coloured ſands, in little incoherent maſſes diſperſed on beds of pyritous earth; and over it is obſerved wood impregnated with a blackiſh bituminous matter: whence it is ſuppoſed to be formed by a reſinous ſubſtance, which has been altered by the ſulphuric acid of the pyrites. It floats too on the borders of the ſea, and is collected on the ſhores of the Baltic in ducal Pruſſia. The mountains of Provence, near the city of Siſteron, the Marquiſate of Ancona, and the Duchy of Spoleto in Italy, Sicily, Poland, Sweden, and ſeveral other countries, likewiſe furniſh it.

40. The colour, texture, tranſparency, and opacity of this bitumen have occaſioned a conſiderable number of varieties to be diſtinguiſhed, which may be reduced to the following according to Wallerius:

1. White tranſparent amber;
2. Tranſparent amber of a pale yellow;
3. Tranſparent amber of a lemon colour;
4. Tranſparent amber of a golden yellow; the *chryſelectrum* of the ancients;
5. Tranſparent amber of a deep red;
6. White opaque amber;
7. Yellow opaque amber;
8. Brown opaque amber;
9. Amber, coloured green, or blue, by extraneous matters;
10. Veined amber.

It is not improbable that amber exiſts in a cryſtalline form, and perhaps it will be found like ſulphur cryſtallized in octahedrons.

41. A ſtill greater number of varieties might be diſtinguiſhed by the accidental circumſtances which it exhibits interiouſly: but the reader ought to be informed, with reſpect to the price attached to ſpecimens of amber, remarkable for their ſize, tranſparency, and the inſects in a ſtate of good preſervation that they contain within them, that it is poſſible to be deceived in this article, as ſeveral perſons poſſeſs the art of giving it tranſparency, of colouring it as they think proper, and of ſoftening it ſufficiently to be able to introduce into it foreign matters. Wallerius

informs us, that the gold coloured amber always owes its tranſparency to nature; and that what has been rendered tranſparent by art is always of a pale hue.

42. Though it is very probable, that this bitumen owes its origin to reſinous vegetable matters, ſeveral naturaliſts have entertained different opinions reſpecting its formation. Some have conſidered it as the hardened urine of certain mammiferous animals: others as an earthy juice, which the ſea has ſeparated, and which, being thrown on the ſhore by its waves, has there been dried and hardened by the rays of the ſun. The latter have diſtinguiſhed it as a peculiar mineral fluid. Such was the opinion of Philemon, an ancient naturaliſt quoted by Pliny; and it was afterward revived by George Agricola. Frederick Hoffmann imagined, that amber was formed of a light oil, ſeparated from bituminous wood by heat, and inſpiſſated by the acid of vitriols. This opinion of Hoffmann we cannot admit: for how is it to be conceived, that an oil, ſeparated in the bowels of the earth, ſhould contain animals, which live only on its ſurface? Hitherto it has been believed, that amber was produced by a reſinous juice, which at firſt flowed liquid from ſome tree: that this juice, buried at a greater or leſs depth in the earth by the changes that have taken place on its ſurface, has been impregnated and hardened by mineral and ſaline vapours circulating in the interior parts of the globe. There is no probability of

its having been altered by concentrated acids, for experience teaches us, that the action of theſe acids would have blackened it, and reduced it to the ſtate of charcoal. Pliny thought that amber was nothing but the reſin of the fir, hardened by the autumnal cold. Mr. Girtanner believes it to be a vegetable oil, rendered concrete by the acid of ants. According to this author it is the ſpecies that Linnæus calls *formica rufa*, by which it is prepared. Theſe inſects inhabit the ancient foreſts of firs, where the foſſil amber is found, which is ductile as melted wax, and becomes hard in the air.

43. Amber does not melt on expoſure to the fire without a pretty ſtrong heat: it ſoftens and ſwells a great deal, without flowing in drops, which diſtinguiſhes it from the reſins, as thoſe melt completely. When it is heated in contact with air, it inflames, and diffuſes a very thick and highly ſcented ſmoke. Its flame is yellowiſh, variegated with green and blue. After combuſtion it leaves a *ſhining black* coal, which yields by incineration a very ſmall quantity of a brown earth. Bourdelin ſays, in his paper on amber (Acad. 1742) that he obtained not quite a gramme of this earth by burning a kilogramme of amber in a teſt. Two hectogrammes and half of the ſame bitumen, burned and calcined in a crucible, afforded him in a ſecond experiment two thirds of a gramme of earthy reſiduum, from which he obtained iron by the help of the magnet.

44. If amber be diſtilled in a retort, and by a graduated fire, we firſt obtain phlegm of a red colour, which is manifeſtly acid: this acid liquor retains the ſtrong ſmell of the amber. Afterward a volatile acid ſalt comes over, which cryſtallizes in ſmall white or yellowiſh needles in the neck of the retort: to this ſalt ſucceeds a light, colourleſs oil, of a very briſk ſmell. This oil gradually grows coloured as the fire gets ſtronger, and becomes at length brown, blackiſh, thick, viſcous, like the empyreumatic oils. While theſe two oils are coming over, a certain quantity of volatile acid ſublimes, which is more and more coloured. After this operation there remains in the retort a black maſs, having the ſhape of the bottom of the veſſel, brittle, and reſembling aſphaltum. George Agricola made this obſervation on the reſiduum of amber after diſtillation near three centuries ago. If this operation be conducted with a gentle and well managed fire, and if a large quantity of amber be employed, all theſe products may be obtained ſeparately by changing the receiver. In general they are received into one veſſel, and rectified afterward by a gentle heat. By this rectification the acid loſes part of its colour. The oil, which becomes black toward the end of the operation only becauſe it carries with it a portion of coally matter, and becauſe the acid has re-acted on its principles, may be rendered very clear and very light by ſeveral ſucceſſive diſtillations. Rouelle the elder has given a very good proceſs for ob-

taining

taining it in this ſtate by a ſingle operation. For this purpoſe the oil muſt be put *with ſome water into a glaſs alembic,* and diſtilled with a heat equal to that of boiling water. The pureſt portion, which alone is volatile at this temperature on account of its lightneſs, comes over with the water, on the top of which it collects. If it be intended to continue in this ſtate, it muſt be kept in ſtone bottles; for the rays of light, that permeate glaſs, will turn it yellow, and even brown, after a time.

This analyſis demonſtrates, that amber is formed of a large quantity of oil combined with an acid. It contains alſo a very ſmall quantity of earth, the nature of which has not been examined, and a few particles of iron.

Oil of amber appears to approach the volatile oils: it has their volatility, their ſmell; it is very inflammable; it appears capable of forming ſoaps with alkalis.

45. The ſuccinic acid, which was at firſt called *volatile ſalt* of amber, was conſidered for ſome time as an alkaline ſalt. Glaſer, Lefevre, Charas, and John Maurice Hoffmann, profeſſor at Altdorf, were of this opinion. Barchuſen and Boulduc ſenior were the two firſt chemiſts, who diſcovered the acid nature of this ſalt toward the end of the ſeventeenth century. All the chemiſts ſince them have adopted this diſcovery, but they have not agreed concerning the nature of this acid. Frederick Hoffmann, conſidering that amber was found in Pruſſia, under ſtrata of

ſubſtances abounding with pyrites, ſuppoſed this ſalt to be formed by ſulphuric acid. Neuman appears to have entertained the ſame opinion. Bourdelin, in the paper quoted above, relates ſeveral experiments he made to aſcertain the nature of this acid. He obſerves in the firſt place, that the acid of amber, obtained by the diſtillation of this bitumen, however white and pure it may be, always contains ſome oleaginous matter: to this matter no doubt it owes its ſmell with the ſort of combuſtibility it poſſeſſes, which it exhibits when thrown on burning coals. He tried ſeveral means of freeing it from this ſubſtance: alcohol would not anſwer his purpoſe: fixed alkali alone, digeſted on amber with a view to take from it its fat and oily part, and obtain its ſalt ſeparate, was equally unſucceſsful; for it only diſſolved a little bitumen, and acquired a lixivial and ſalt taſte like muriate of ſoda. In fine, Bourdelin could diſcover no better proceſs for uniting the acid of amber pure and deprived of oily matter with fixed alkali, than detonating a mixture of two parts of nitre with one part of this bitumen. He lixiviated the reſiduum of this detonation with diſtilled water. This lixivium was of an amber colour: it precipitated the nitric ſolution of ſilver in white flakes, and that of mercury of the ſame colour. Several other metallic ſolutions were equally decompoſed by it: but Bourdelin conſidered only theſe two as concluſive. They appeared to him to ſhow, that the acid of amber is the ſame with that of marine

ſalt,

ſalt, ſince it exhibits the ſame phenomena with the nitric ſolutions of mercury and ſilver. The lixivium of the detonation of amber with nitre, having been ſuffered to evaporate in the open air, afforded a mucilaginous ſubſtance, in the midſt of which were gradually depoſited elongated ſquare cryſtals, the figure of which, their ſalt taſte, their decrepitation on burning coals, and particularly their conſiderable efferveſcence, as well as the ſmell of muriatic acid which they emitted, when concentrated ſulphuric acid was poured upon them, indicated to our author, that this muriatic acid was united with the baſe of nitre in them.

46. Notwithſtanding this analyſis, which is very accurate for the time when Bourdelin made it, the chemiſts who have ſince examined the acid of amber have not found it analogous to the muriatic acid, but have diſcovered all the characters of an oily vegetable acid in it. Bergman, who appears to have adopted this opinion, gives the following details of the properties and elective attractions of this ſubſtance.

The ſuccinic acid, obtained by ſublimation, and purified by ſucceſſive ſolutions and cryſtallizations, forms cryſtallizable and deliqueſcent neutral ſalts with pot-aſh and ammonia.

With ſoda it yields a ſalt, which does not attract the moiſture of the air.

United with lime, and with barites, it produces ſalts but little ſoluble. Magneſia forms with it a thick ſubſtance like gum.

It diſſolves metallic oxides, and the ſuccinates produced by theſe ſolutions are moſt of them cryſtallizable and permanent.

Barites, lime, and magneſia, according to him, take the ſuccinic acid from pot-aſh and ſoda. Barites decompoſes the ſuccinates of lime and magneſia, and lime-water precipitates magneſia from its union with this acid.

47. The examination of the chemical properties of this bitumen has been carried no farther. Even the manner in which acids are capable of acting on it is not known. Frederic Hoffmann aſſerts, that it may be entirely diſſolved in lixivium of cauſtic alkali, and in ſulphuric acid. We know too, that the volatile oil of amber is capable of uniting with cauſtic ammonia, and forming by ſimple mixture and agitation a ſort of liquid ſoap, of a milky white colour, and a very pungent ſmell, which is prepared in the ſhops under the name of *eau-de-luce*: and laſtly, that this ſame oil diſſolves ſulphur by the help of a ſand-heat, and forms a preparation called ſuccinated balſam of ſulphur.

48. Amber is employed in medicine as an antiſpaſmodic: it has been recommended in hyſterical affections, ſuppreſſed menſtruation, gonorhoea, fluor albus, &c. It is adminiſtered in its native ſtate, after having been waſhed with warm water, and reduced to a fine powder by levigation. It is particularly uſed for corroborant and reſolutive fumigations, the powder of this bitumen being thrown on a hot brick, and

the fumes it emits being directed to the part on which it is intended to act.

The liquid acid of amber, and its concrete acid, are both conſidered as pectoral, inciſive, cordial, and antiſeptic. They are likewiſe preſcribed as powerful diuretics.

The oil of amber is employed externally and internally for the ſame purpoſes as amber itſelf; but it is adminiſtered in ſmaller doſes, as its activity is greater.

The ſuccinated balſam of ſulphur, which is given in doſes of a few drops in appropriate liquors, or mixed with other ſubſtances to form pills, has been found beneficial in humoral and pituitous affections of the lungs, kidneys, &c.

A ſyrup is prepared with the liquid acid of amber and opium, called ſyrup of amber, which is adminiſtered with advantage as anodyne, antiſpaſmodic, and a ſoother of pain.

The *eau-de-luce,* which is prepared by dropping a few drops of oil of amber into a phial full of cauſtic ammonia, and ſhaking the mixture till it has acquired a milky white colour, has long been uſed as a very active ſtimulant in ſyncope: it is held to the noſtrils, the nerves of which it ſtimulates; and by the ſhocks it excites, it reanimates the motions of the fluids, and revives the patient.

49. The fineſt pieces of amber are cut and turned in the lathe to make vaſes, heads for canes, necklaces, bracelets, ſnuff-boxes, &c. Trinkets of this kind are no longer prized

among us, ſince diamonds and precious ſtones have been in faſhion; but they are ſent to Perſia, China, and ſeveral other countries, where they are ſtill eſteemed as great rarities. Wallerius ſays, that the moſt tranſparent pieces may be uſed for making microſcopes, burning mirrors, priſms, &c. It is ſaid, that the King of Pruſſia has a burning mirror of amber a foot in diameter; and that there are in the cabinet of the Duke of Tuſcany a pillar of amber ten feet high, and a very fine chandelier made of the ſame ſubſtance. Two pieces of this bitumen may be united into one by wetting them with a ſolution of pot-aſh, and joining them together after heating them.

SECTION IV.

Of Petrified Wood.

50. The laſt alteration to be conſidered in vegetables buried in the earth relates to what is called petrified wood, or petrified vegetable ſubſtances in general. A word or two will be ſufficient, to give a proper idea of this pretended alteration. It is a great error to ſuppoſe, that a vegetable ſubſtance is converted into ſilex, as the term of petrified wood ſeems to imply. We cannot doubt, however, that there exiſt foſſil ſilicified ſubſtances, which exhibit the form and

texture, not merely of wood in general, but even of particular kinds of wood. In reality it is not from the appearance of ſimple fibres, as is ſo often done, that we can diſtinguiſh a petrified wood. Moſt of the ſpecimens we find under this name in collections of natural hiſtory are by no means real ligneous ſubſtances, they are only ſpecies of jaſper with lines or ſtreaks in the ſhape of fibres. For a foſſil to be juſtly ranked in the genus of petrified wood, the ligneous fibres, or rather what occupies their place, muſt be arranged in concentric and annual layers, and beſides, the prolongations of the medullary ſubſtance, iſſuing from the centre and ſpreading to the circumference, muſt be diſcernible among them.

51. Where this laſt mentioned ſtructure exiſts, it announces a petrified wood, and it is the only ſtructure that does ſo inconteſtibly. At the ſame time it is well known, that we are not by this to underſtand the original woody ſubſtance entire, with its figure, texture, and dimenſions, to be converted into ſiliceous matter: it is neceſſary to form a different idea of this foſſil, bearing as it does an organic appearance. The wood, the tree, the leaves, the fruit, or whatever other vegetable ſubſtance is improperly termed petrified, has been deſtroyed gradually, and almoſt atom by atom, in a moiſt earth, where it has left a hollow mould, as gradually filled up by ſiliceous earth, which the water has brought thither. Thus it is not in reality wood petrified,

but ſimply wood replaced by ſiliceous matter, mixed likewiſe with other earths and with metallic oxides. This kind of ſilicification therefore, is a proof of the complete deſtruction of the vegetable matter, and of the diſappearance of every thing that conſtituted its elements. There is nothing beyond this in the alterations, of which vegetables are ſuſceptible.

SIXTH ORDER OF FACTS

RESPECTING VEGETABLE COMPOUNDS.

Of the Chemical Phenomena, which living Vegetables exhibit, or Vegetable Phyſiology explained by Chemical Powers.

ARTICLE I.

Of Vegetables conſidered as a ſort of Chemical Implements or Apparatuſſes.

1. IN the beginning of this ſection I remarked, that vegetables might be conſidered as beings intended by nature to begin the organization of crude matter, to form triple combinations of ſimple ſubſtances, compounds to which nothing analogous can be found among foſſils properly ſo called, to diſpoſe theſe primitive materials of the earth and atmoſphere in order to become the ſource of life, and conſequently to eſtabliſh a communication, or uninterrupted paſſage, between minerals and animals; ſo that the life of animate beings could not be maintained without the proceſs of vegetation.

2. From this phenomenon, now ſufficiently proved, it follows, that plants are truly chemical apparatuſſes or implements, employed by nature to produce combinations, which would not take

place without theſe implements, and which cannot exiſt without vegetable organization: but nature, as admirable in the ſimplicity of her means, as in the conſtancy and regularity of her operations, finds in one and the ſame mechaniſm both vegetable organization itſelf, and the appropriation of crude matter neceſſary for the ſupport of animal life; or rather one of theſe movements is the unavoidable conſequence of the other, as they neceſſarily accompany and are abſolutely dependant on each other.

3. Thus the analyſis of vegetables ought not to be confined to the chemical examination of ſubſtances extracted from plants, and already deprived of life; it ſhould be extended to the conſideration of the properties of theſe ſubſtances contained entire in vegetables, and ſharing their vital movements; it ſhould inquire into the production of the ſeveral changes they undergo, the ſucceſſive ſtages by which they are elaborated, and the uſes which each is deſtined to fulfil in vegetable life. It is the whole of theſe facts which I term the chemical phenomena of living vegetables, and which I place at the end of the five orders of facts previouſly examined, becauſe the knowledge of theſe was calculated to lead us to the knowledge of the others.

4. Previous to the riſe of the pneumatic chemiſtry, ſcience poſſeſſed no means of ſtudying, or even of forming an idea of this beautiful part of phyſics. The firſt experiments that were made, from thoſe of Hales to thoſe of Duhamel and

Bonnet, ſeemed to belong to knowledge of a different claſs from any thing chemiſtry could furniſh; and this ſcience, at that time too modeſt, and too much confined in its views, was employed merely in extracting, ſeparating, purifying, and preſerving the different materials of plants, and particularly in applying them to medicinal purpoſes. It was the diſcovery of elaſtic fluids, that produced a more intimate connexion between the views of chemiſtry and thoſe of vegetable phyſics; and led us to perceive, that it would be thenceforward impoſſible to ſtudy and conceive the mechaniſm of vegetation, without combining the data and the means furniſhed by chemiſtry with the experiments formerly made.

5. Accordingly from this period chemical and pneumato-chemical apparatuſſes began to be employed for ſtudying the phenomena of vegetation; for aſcertaining what it is that plants derive from earth, air, and water, what they borrow from light and heat, how the matters they abſorb afford them nutriment, and how they become vegetable compounds; in a word, in what vegetable life really conſiſts. This firſt labour opened a new and vaſt career to natural philoſophers, in which they have yet advanced but a few ſteps; a career beſet with difficulties far greater than the analyſis of dead vegetable ſubſtances. It is a rapid ſketch of theſe firſt ſteps, and of the diſcoveries to which they have led, that I range in this laſt order of facts.

Article II.

Of the Nutrition of Vegetables in general.

1. When we reflect on the end which chemiſtry ought to propoſe to itſelf, in explaining the yet myſterious mechaniſm of vegetation, we perceive, that the firſt and moſt important problem it has to ſolve conſiſts in determining how crude or inorganic matter, foſſil or aëriform ſubſtances, received into the veſſels of plants, there take the nature of vegetable compounds: how with ſimple ſubſtances, or binary compounds, vegetables form the matters which elongate, unfold, enlarge, and nouriſh them, increaſe their bulk, and thus give birth to all the ſucceſſive phenomena which their life exhibits.

2. To find the ſolution of this problem, it muſt firſt be obſerved, that, in moſt circumſtances of vegetation, the matters, which ſerve as the primary nouriſhment of plants, ſeem reducible almoſt to nothing, when their tenuity is compared with the ſolidity of vegetables. We know, that a number of vegetables grow on hard and ſolid ſtones, which can impart nothing to them: that ſuch is the firſt vegetation, which takes place in lichens and moſſes on quartz and granite: and that apparently the matter by which plants are nouriſhed may be brought to

them ſolely and abſolutely by the air, ſince it cannot be imagined, that the ſilex condenſed in ſtones can anſwer this purpoſe

3. The ſame reflection may be made on plants, and even on trees, ſometimes of conſiderable bulk, which ſpring up in pure ſand, grow and even ſhoot forth deep roots in compact ſandſtones, or in the clefts of lava of extreme hardneſs. After this we muſt not be aſtoniſhed, to ſee the ſtones of buildings covered with vegetations, the ſmallneſs of which and their extenſive ſurfaces announce, that the contact of air alone is ſufficient for their exiſtence.

4. But if we may conclude from this general and conſtant obſervation, that ſolid or pulverulent aliment is not abſolutely neceſſary to vegetables, it is not the ſame with regard to light, caloric, air, and water. Too many facts here concur to leave us any doubt, that theſe ſubſtances, ſo abundant around the globe, on its ſurface, or in its cavities, and which nature has placed in every part, are indiſpenſable to their exiſtence: and that in the abſence of more ſubſtantial nouriſhment, which the ſoil ſo frequently refuſes, plants draw from theſe immenſe reſervoirs of life and matter the ſubſtance requiſite for their ſupport. We muſt therefore ſeparately examine the influence of each of theſe primitive matters on vegetation.

ARTICLE III.

Of the Influence of Light on Vegetation.

1. IT is a fact long known, that vegetation is very ſtrikingly affected by the light of the ſun. Plants appear to ſeek it, and to turn toward the ſide whence it comes. It is obſerved on the mantlepieces, on which bulbous rooted flowers are put to grow; for theſe flowers incline toward the windows. It is remarked in foreſts, where trees are very cloſe together: in this caſe the trees ſhoot upward, and by their vertical poſition ſeek the light one over the other, according to their vigour. Their aſcent is even promoted by planting them at little diſtance from each other.

2. This kind of affection in vegetables for light is ſuch, that we ſee plants encloſed under wooden frames which have but a few chinks, and where the air circulates underneath, incline toward the chinks, and bend down to ſeek the rays of light. Herbs ſown in ſubterraneous places ſhoot toward the air-holes, and riſe along the paſſages through which a portion of light is tranſmitted.

3. All vegetation that takes place in the ſhade is accompanied with phenomena, which ſtrongly prove the influence of light. From the feeble herbs which grow beneath ſtones, between ſhady

tufts of moſs, or in the ſubterranean cavities of mines, to thoſe which are ſown for the purpoſe in cellars; theſe vegetables every where exhibit a looſe, ſoft, and watery texture, herbaceous and ſlender ſtalks or ſhoots, without vigour, without taſte, without colour. Their fibres, drenched with fluids, and as it were œdematoſe, never aſſume the woody character. Their taſte is always aqueous and inſipid; they never become aromatic or odoriferous. They are generally called *etiolated* or blanched plants. The ſame phenomenon takes place in leaves which envelope and cover one another; either by enſheathing, or by folding over one another, as in lettuces, ſuccory, cardamoms, which gardeners keep cloſe together by bands, and in cabbages, &c. The external leaves are very green, thoſe within are white and *etiolated.*

4. On the contrary, the places where light falls more directly, the climates ſituate under the equator, or near the equinoctial line, abound with hard, woody, coloured, aromatic vegetables. Theſe are the country of hard woods, of very dark and often ſolid leaves, of volatile oils, of reſins, of the camphor principle of aromatics, of very ſapid and powerfully medicinal plants, and even of the moſt terrible vegetable poiſons. This effect is very ſtriking alſo in temperate climates, with reſpect to plants growing freely in the open air, in fields where they receive the light of day on every ſide, compared with others of the ſame ſpecies raiſed by art in the ſhade of under-ground places, as has been

done with different varieties of endive and ſuccory, cultivated for winter ſallad.

5. This influence of light is ſhown even by the effect of lamps, according to the intereſting experiments of Citizen Teſſier at Paris, and of Mr. Humboldt at Berlin. The latter gentleman, it is true, has proved moreover, that the contact of ſome other elaſtic fluids may in a certain degree ſupply the place of light, and produce analogous effects, as I ſhall ſhow farther on: but it is not the leſs true, that the artificial light of lamps produces an action ſimilar to that of natural light; and that by increaſing their number, we may produce in vegetation phenomena more or leſs ſimilar to thoſe which are ſeen to be effected by the rays of the ſun.

6. The cauſes of this effect of light on vegetation have not yet been decidedly diſcovered, or at leaſt ſo confirmed, that no doubt about them remains in the minds of natural philoſophers. Some think that it is by a real combination with vegetable matter that it changes its nature, and that it particularly effects its combination: others aſſert, that its contact merely favours the decompoſition of water and carbonic acid, and the fixation of the hidrogen of the one and the carbon of the other, in the vegetable compounds, and the evolution of their oxigen in a ſtream of gas. We ſhall ſee preſently, in the ſubſequent articles, the facts by which I am led to imagine the ſecond opinion more pro-

bable than the firſt. Still it muſt be obſerved, that the effect of light on vegetables, to whatever cauſe it may be owing, is to warm them, to increaſe their power of ſuction, to reſiſt the ſeptic decompoſition, to colour them, to give riſe to oleaginous, aromatic and acid ſubſtances, to promote the evolution of oxigen gas, and to render vegetation in general very active.

ARTICLE IV.

Of the Influence of Air on Vegetation.

1. THE great influence of the air on vegetation is no more to be doubted than that of light; or rather even thoſe natural philoſophers, who do not conſider its influence to be ſo powerful, at leaſt admit the great neceſſity for air in this operation of nature; and in fact all the phenomena, which plants exhibit, combine to prove the utility and even neceſſity of air in vegetation. The vigour with which plants thoroughly expoſed to it puſh forth, and the languor which vegetables deprived of it diſplay, are well known.

2. It is a very certain and conſtant fact, that there is not one plant, which, if confined under a veſſel where the air is not renewed, though all other circumſtances ſhould be completely favourable to it, would not die in a longer or

ſhorter time, according to the quantity of this fluid allowed it: while if it be taken out of this priſon, the moment it begins to droop, and placed in the open air, or if freſh air, eſpecially oxigen gas, be let into the veſſel, it ſoon reſumes its priſtine ſtrength and vigour. This phenomenon is ſeen on a much larger ſcale, when we compare the diminutive ſtate and little growth exhibited by the ſame plant in a cloſe and confined garden, with the ſize which it acquires in a ſpacious field; the ſmallneſs of crops of corn in the neighbourhood of trees, with the abundance afforded in an open country; the difference in many vegetables growing in the depth of dark and ſhady foreſts, from the height and ſtrength they attain in an open ſituation, and on the ridges of hills or mountains.

3. But in what does this influence conſiſt, and where is the cauſe to be found? The air of the atmoſphere is a fluid that abounds with ſuch different matters, beſide the proper nature of its two component parts, oxigen gas, and azote gas, and the ſmall portion of carbonic acid gas, which it always contains, particularly with regard to the very different quantities of water, which it diſſolves according to a multitude of various circumſtances, that it is very difficult to determine by what material it is ſo eminently and indiſpenſably conducive to vegetation. Hence, this part of the problem of the phyſiology of vegetation is yet perfectly

new, and has never been ſolved. Natural philoſophers have offered different hypotheſes, the truth of which has not yet been confirmed by experience. Some have ſuppoſed, that air, penetrated into vegetables, and ſupported life in them by a kind of reſpiration, as it does in animals. Hales was inclined to this idea, from his experiment in which he had ſeen the air paſs into the ſtalks of plants, when he made a vacuum round the lower part of them incloſed in the receiver of an air-pump. But this experiment affords nothing applicable to the mechaniſm of vegetation, ſince the vacuum, which is the cauſe of this paſſage of the air, can never take place in plants. We can never find any thing in theſe that reſembles the reſpiration of animals.

4. Other natural philoſophers have ſuppoſed that the air conveys nouriſhment to plants, and that it is wholly, or almoſt wholly, derived to them from the atmoſphere; that for plants to find their nouriſhment in it, this fluid muſt always contain an equal proportion of its two elaſtic fluid principles; that when its oxigen gas, which is particularly ſubſervient to vegetation, is exhauſted, it can no longer maintain this operation, and then the plants die. As to the neceſſity of this renovation, they admit it in that of receiving a ſort of excrements, or a vegetable perſpiration, which converts its oxigen gas into carbonic acid, or in that of furniſhing by its abſorption one of the aliments of the vegetable.

getable. Both theſe ideas may be true at the ſame time. No direct or ſufficiently accurate experiment has yet proved, that either of them merits our excluſive preference to the other.

5. The neceſſity of air to the ſupport of vegetable life appears to depend ſo eſſentially on the preſence of oxigen gas in this fluid, that, according to the experiments of Mr. Ingenhouſz, plants may be made to vegetate in gaſes that are not reſpirable, particularly in azote gas and hidrogen gas, provided a certain quantity of oxigen gas be introduced into them. It appears that the oxigen gas, becoming the recipient of the carbon given out by the plants, which is one of their excrements, thus paſſes to the ſtate of carbonic acid, which is capable itſelf of ſerving anew the purpoſes of vegetation, as I ſhall ſhow in one of the following articles.

Article V.

Of the Influence of Water on Vegetation.

1. WATER is ſo uſeful to vegetation, and this utility is ſo apparent to all men, that the majority of natural philoſophers conſider it as the *primum mobile* of the growth of plants, and as the moſt uſeful of the matters that enter into their compoſition, from the date of the ex-

periments of Van Helmont, Boyle, and Duhamel, who made trees grow in pure water for many years; to thoſe of Tillet, who has proved that the nature of the ſoil in which ſeeds germinate is almoſt indifferent, and that they require ſcarcely any thing for their generation but the preſence of water. All the experiments of philoſophers, all the obſervations of naturaliſts and huſbandmen, combine to prove the great utility of water in vegetation: and its ſuperior importance to all other matters is a fact generally acknowledged, on which no doubt can ariſe, and the explanation of which has much engaged the attention of the learned.

2. If ſtill more to confirm this primary influence, this great utility of water in vegetation, it were neceſſary to add to the accurate but always confined experiments of natural philoſophers effects equally concluſive by their authenticity and magnitude, experiments made on a large ſcale, we might cite the fertility of places always wet, the richneſs of watered meadows, the advantage that land through which rivulets flow poſſeſſes over a dry and acrid ſoil, we might appeal to the celebrated experience of the annual inundations of the Nile, and the fertility of Egypt in conſequence of this inundation, conſidered by the inhabitants as the eſpecial favour of Heaven. Facts borrowed from practical agriculture, and the hiſtory of the productions of different countries, would furniſh irrefragable proofs of this well eſtabliſhed

influence of water on vegetation, proofs that might even be ſtill more accumulated with advantage. Another equally ſtriking might be found in the remarkable induſtry of the gardeners who cultivate the marſhes near Paris. From theſe marſhes, ſituate all around that vaſt city, they derive great profits, they cover the ground with abundant and uninterrupted crops, and they are indebted for this almoſt aſtoniſhing ſeries of vegetable production to the enormous quantity of water, which they are inceſſantly conveying into their grounds, and the continual waterings, with which they fertilize them.

3. One important queſtion ariſes reſpecting this influence of water in vegetation: to endeavour to ſolve it, we muſt begin with obſerving in what manner it acts on the different organs of plants. There is no doubt that it paſſes through the roots; ſince a dry, withered plant erects itſelf, is refreſhed, and continues to vegetate, when its roots are put into water; ſince we ſee coloured liquors aſcend in the veſſels of young white radicles, and impregnate them with their colour; and laſtly, ſince every plant, every tree of which the roots are more or leſs watered or humectated, puſhes with more or leſs vigour, and fulfils all its functions. This water aſcends into the ſtalks, and diffuſes itſelf through all the parts of plants; it flows off or eſcapes in part by the leaves, which pour it out into the atmoſphere; and the more abundant this tranſpiration is, in conſequence of the

heat and diſſolving quality of the air, the more conſiderable is the ſuction of water by the roots.

4. It is equally indubitable, that germination is produced, if not excluſively, at leaſt in part, by the help of water; ſince ſeeds before they germinate require its abſorption; ſince all dry matter excludes germination; and ſince moiſt earth, or ſome wet ſubſtance or ſurface, is neceſſary to occaſion it. It does not appear, however, that it can take place from the action of water alone, and that ſeeds wholly immerſed in water can germinate: it is even imagined, that this does not take place in aquatic plants, the ſeeds of which ſhoot out only on the ſurface of the water, and ſome of which afterward ſink in the veſſel, in order to attach to it their roots. But is it only by the ſeeds during germination, and by the roots during vegetation, that water thus penetrates vegetables; and is there no other way, by which it introduces itſelf into plants?

5. Moſt of the natural philoſophers, who have employed their attention on vegetable phyſics, have thought that the leaves of plants were full of veſſels and abſorbent pores, by which they inhaled or ſucked up from the atmoſphere the water ſeparated from it in the ſtate of dew, and that this abſorption, which might ſupply the place of that of the roots when the earth was dry, was carried on particularly by night, and when the dew fell. In ſupport of this opinion, ſome have even adduced the difference between the two ſurfaces of leaves, ſo well obſerved by

Bonnet, and which is ſo great in their ſtructure as well as functions, that, if placed on water with the lower or rough ſurface next to it, the leaves remain green, and vegetate; but if placed on it with the upper or ſmooth ſurface downward, they dry and periſh, or live a much ſhorter time than the others. The former ſurface was eſteemed abſorbent or inhalant, and the latter exhalant. But we do not ſee how, or by what power, the water of the atmoſphere can penetrate them; how it can inſinuate itſelf into the veſſels of plants, without repelling the fluids contained in thoſe veſſels, unleſs we ſuppoſe a vacuum; and this, we know, is not demonſtrated.

6. In whatever manner, or by whatever way, water inſinuates itſelf into the veſſels of plants it is ſtill certain that it paſſes through them continually, that it penetrates all their organs and every part, that it is inceſſantly renewed in them, and that this renovation and circulation are neceſſary to the exiſtence of vegetables, ſince the ſtrength and quickneſs of vegetation pretty accurately correſpond to the quantity of water abſorbed. Nothing more is wanting, than to know for what purpoſe water is uſeful in the nutrition of vegetables; for the growth of plants is the effect of its introduction into their interior parts, its ſtay there, and its paſſage through them. All that the ſtate of ſcience has hitherto enabled us to diſcover is what follows. The water which paſſes into the roots,

and is filtered through them, carries with it at firſt all that it has taken from the earth, which is impregnated with it; and in this point of view it is the vehicle of all that the earth can contain for the food of plants.

7. It is at preſent fully proved, that water impregnated with air, and with ſome ſoluble elaſtic fluids, is much more uſeful to vegetation than water deſtitute of air, or boiled water. Hence ſnow-water, which, as the ſnow gradually melts, reſumes the air it had loſt, and in this ſtate of aëration inſinuates itſelf into the earth, where it waters the roots, occaſions ſuch a quick and remarkable vegetation in the beginning of ſpring. For the ſame reaſon the water of a fine and gentle rain, which, after having traverſed a portion of the atmoſphere, and taken from it a conſiderable quantity of air, uniformly covers and gradually penetrates the ſoil, in which the roots of plants are fixed, gives activity to the growth of the plants. It is remarked alſo, that when plants are watered from a well or a ciſtern, their vegetation is much feebler than when the water employed for the purpoſe has flowed a certain length of time in contact with the air, ſo as to have been able to ſaturate itſelf with it.

8. The different matters capable of contributing to the nouriſhment of vegetables, which are contained in the earth, are there in a dry and ſolid form, which does not allow them to penetrate the texture of roots, or conſequently

that of the ſtalks of plants. It is the water which conveys the molecules of different natures, that may ſerve as food to plants, either ſuſpended from being in a ſtate of minute diviſion, or as actually diſſolved by an appropriate chemical agent. Thus it is water that imparts to theſe molecules, by which vegetables are nouriſhed, that liquid form which is ſuitable to them, and without which they could never be introduced into the texture of plants. The more of this ſolvent paſſes into them, the more alimentary matter we muſt conceive to be carried with it into the organs of plants. We ſhall ſee that water can thus convey even ſiliceous earth, which is actually found in the analyſis of vegetables after the ſeparation of all the ſoluble, ſaline, inflammable, and other matters.

9. It is almoſt uſeleſs to point out that water, by inceſſantly paſſing along the veſſels of vegetables, conveying into them different ſubſtances adapted to increaſe their ſubſtance and add to their growth, diſtends, fills, ſwells, and elongates their canals; that it ſupports their parenchyma, their air-veſſels, their texture in general, in a proper degree of diſtention; and thus we readily conceive how, after a drought, a drying wind, or expoſure to the burning rays of the ſun, drooping plants, the wrinkled, bowed, and falling leaves of which threaten even to paſs into a ſtate of greater ſuffering, and to certain death, if their thirſt be not ſatisfied, riſe up, exert themſelves, diſplay their leaves in ſuch a

degree of extenſion, and with ſuch openneſs, ſpread, and colour, as are ſuitable to their exiſtence, and ſoon begin to puſh forth with more vigour than before.

10. No perſon doubts likewiſe, that water in its natural ſtate, and without decompoſition, enters as ſuch into plants for one of their conſtituent principles, and makes a part of the elements of which they are compoſed. Thus water forms the baſis of the ſap, and of all the juices found in them; thus it holds in ſolution their acids, ſalts, and extractive matter; it ſoftens their mucilages, &c. This was the only idea the ancient chemiſts had of the uſe of water in vegetation; and they carried it ſo far as to imagine, that water exiſted in a ſolid ſtate in ſeveral vegetable compounds. At preſent we have a greater opinion of its vegetative utility.

11. Since Lavoiſier and Citizen Berthollet occupied themſelves with this ſubject in 1785 and 1789, ſince Ingenhouſz diſcovered, that leaves immerſed in water, and expoſed to the ſun emitted oxigen gas, it has been imagined that water was decompoſed in the veſſels of vegetables, and particularly in thoſe of their leaves; that this decompoſition was promoted by the contact of light, eſpecially by that of the ſun; that the effect of this decompoſition was the reverſe of that which chemiſts accompliſh by means of combuſtible ſubſtances, the water depoſiting in the plants its hidrogen, which formed in part their oils, extracts, and colouring matter; that a portion

a portion of its oxigen at the ſame time became fixed in them to conſtitute their mucous, ſaccharine, feculent, and other oxides, or vegetable acids; that the greater part of this oxiding and acidifying principle, detached or ſeparated from the hidrogen, and diſſolved by the caloric of light, aſſumed the form of gas, and iſſued frequently with rapidity from the ſurface of vegetables, and particularly from their leaves, to diffuſe itſelf in the atmoſphere.

12. Thus in the diſcovery of the decompoſition of water in leaves expoſed to the rays of the ſun, were found at once an ingenious explanation of the great utility of this fluid in vegetation, and a ſource of the two principal elements which enter into the compoſition of the ſubſtances found in plants, among which hidrogen is well known to act the chief part; and we are enabled to conceive how nature renovates the atmoſphere by a very ſimple mechaniſm, and imparts to it by means of vegetation, which is in this reſpect a decombuſtion, the oxigen that ſo many cauſes inceſſantly combine to take from it. Thus from the knowledge of a ſimple phenomenon, and of one ſingle cauſe, we are enabled to account for a number of complicated circumſtances and facts, the exiſtence of which, or their connection with natural philoſophy, was not before conceived. It muſt be remarked, however, that there are ſome modern philoſophers who deny this decompoſition of water by living leaves, aſſiſted

by expoſure to the ſun: we ſhall ſee preſently on what their denial of it is founded.

ARTICLE VI.

Of the Influence of carbonic acid Gas, and of ſome other Gaſes on Vegetation.

1. AFTER the principal diſcoveries of the differences and properties of the various ſpecies of elaſtic fluids, attempts were made to aſcertain their action and influence on vegetation. It was ſoon perceived, that no gas but common air and oxigen gas could maintain this grand phenomenon, and that in this reſpect it exhibited a very ſtriking analogy to the life of animals, and to combuſtion.

2. But it was perceived, in the courſe of theſe reſearches, that the purity of the air was far from being as indiſpenſable for the ſupport of vegetation, as for that of reſpiration; that vegetables continued to live in air too much altered or ſpoiled, to be capable of ſupporting animal life; that moſt of them even ſhoot forth more vigorouſly in an air ſomewhat impure than in very good air; and that in the latter caſe the ſpoiled air, which ſerved for this more vigorous vegetation, was perceptibly improved, at leaſt, in the firſt periods of this

action, inſtead of continuing to grow noxious, as it does in every ſort of combuſtion, and by the reſpiration of animals.

3. When the laſt-mentioned fact, that of plants vegetating with more vigour in ſpoiled air than in very pure air, had been confirmed by experiments ſufficiently numerous, it remained to be determined, to what this ſingular effect was owing; what kind of alteration in the air, ſo far from being injurious to vegetation, ſeemed to be advantageous to it; what gas, diminiſhed or added to the atmoſphere, produced this ſingular effect; and by what mechaniſm it was in reality brought about. Though this is not yet completely determined, ſome important facts however have been diſcovered in the reſearch, which may ſerve at leaſt to ſolve a part of the great queſtion included in the inquiry.

4. It has been diſcovered, both by the analyſis of air ſpoiled by animals and ſtill fit for vegetation, and by the artificial compoſition of mixtures of airs in which plants have been ſet to vegetate, that this advantage to vegetation, of air previouſly uſed, was owing to a certain portion of carbonic acid, contained in it much greater quantity than in common air. Mr. Ingenhouſz convinced himſelf, that by introducing into azote gas and into hidrogen gas, either of which alone is incapable of ſupporting vegetable life, a certain quantity of carbonic acid gas, they became capable of it. Mr. Humboldt has ſince found, that eight or ten hun-

dredth parts of carbonic acid gas, added to atmoſpheric air, rendered it extremely fit for vegetation; and that ſuch was ſometimes the ſtate of a certain part of the air of mines, where a whole claſs of crypogamia plants germinated, and ſhot forth briſkly.

5. This utility of carbonic acid to vegetation, and the influence it manifeſtly has on this function, are diſcoverable alſo in water impregnated with it, and which is known to be much better for watering plants than common water. There is ſcarcely any ſubterranean water, filtered through ſtrata of vegetable mould, which does not contain ſome portion of carbonic acid; and this water, juſt as we find with reſpect to animals, not only is without danger like the pure acid gas to the ſupport of vegetable life, but even contributes in an eminent degree to augment its activity, and increaſe its energy.

6. The action which this acid produces, either as gas added to the air in which the plants are immerſed, or as diſſolved in the water which their roots abſorb, or as combined with the aqueous vapour or dew which moiſtens their leaves, appears to be owing to its decompoſition, which is effected in the texture itſelf of theſe laſt mentioned organs, and is ſhown by the experiments of Mr. Ingenhouſz and Citizen Sennebier. In this kind of decompoſition, analogous to that which is effected by phoſphorus heated with carbonate of ſoda, that of lime, &c. the carbon of the carbonic acid is ſeparated

from its oxigen, and combines with hidrogen, oxigen, &c. to form the different immediate materials of plants, which we know contain theſe primary principles, and the greater part of its oxigen, which forms 0,72 of it, is evolved as an elaſtic fluid, mixing with the air, and meliorating it.

7. In this effect we cannot but perceive one of the ſources of the carbon that exiſts in plants, and which ſo frequently conſtitutes the greater part of the elements that compoſe them; and while this manner of explaining the mode of intromiſſion into the ducts of vegetables, gives a very ſatisfactory reaſon for the uſeful influence, that the carbonic acid gas contained in ſpoiled air has on plants, it has the advantage of enabling us to underſtand one of the moſt difficult, moſt abſtract, and moſt profoundly hidden phenomena exiſting in vegetable phyſics, that of the formation of the carbonaceous compounds, which exiſt ſo abundantly among the materials of plants.

8. It is to the ſame cauſe only we can aſcribe an effect equally remarkable produced on vegetables by carbonated hidrogen gas. This gas, when pure, kills theſe organic beings pretty quickly; but mixed in a certain proportion with atmoſpheric air, it manifeſtly increaſes its productive property in vegetation. There are even circumſtances well known by farmers, in which this gas, eſcaping from marſhes, pools, bogs, rotten dunghills, the water draining from them,

ſtables, &c. and enveloping plants completely in all parts, makes them grow with great rapidity, and ſometimes even, amid this rapid growth, occaſions them to contract a ſmell and taſte, which atteſt its influence. It is too evident, to require a more minute explanation here, that this effect is owing to the ſame cauſes, and depends on the ſame theory, as the influence of carbonic acid; and that, though the action of carbonated hidrogen gas be more ſpeedy than that of the carbonic acid, it ariſes from the carbon it contains being more naked, and more diſpoſed to penetrate the veſſels of plants, than that which being united with oxigen, adheres more ſtrongly to it, and is more difficult to be ſeparated.

ARTICLE VII.

Of the Influence of the Soil, and of its Amendment, on Vegetation.

1. OBSERVING vegetables fixed in the earth, men have always been led to think, that the ſoil in which their roots were buried furniſhed the principal matter of their nouriſhment, and that they derived from this all the qualities by which they are diſtinguiſhed. Hence, the ancient no-

tion of the connection of ſoils with their productions, which has always conſtituted one of the principal or fundamental dogmas of agriculture. The ſame ideas of the influence of the earth in favour of this or that vegetable, or giving to ſuch a plant a peculiar character, have always been propagated from ancient times to the preſent; and there is not one ſingle farmer in our days, who is not perſuaded, that plants derive from the ſoil in which they grow characters depending on it excluſively, ſuch as a particular flavour, a peculiar ſmell, &c.

2. In reality there can be no doubt, and too many examples confirm it, that the quality of ſoils is communicated to the vegetables planted in them: it conſtitutes what is called the *taſte of the ſoil.* Thus grapes, fruits, and particularly pulſe, ſtalks, leaves, and roots, acquire in marſhes a taſte, ſmell, conſiſtence, and colour, manifeſtly depending on the qualities of the earth where they have grown. This remark may be extended even to wines produced by fermentation, the reſult of a profound alteration experienced by vegetable juices: we know that they partake of the nature of the ſoil where the vine has grown, and that we may diſtinguiſh in what is called the *bouquet,* or peculiar ſmell, the difference of a dry, ſandy, ſiliceous, flinty ſoil, or too wet, too rich, and too ſtrong ground. Theſe general data, of which we cannot doubt, as well as thoſe reſpecting the particular diſpoſition of a particular ſoil to give

birth

birth to certain productions, irrefragably prove, that every ſoil has a direct influence on vegetables growing in it.

3. But though this truth be well eſtabliſhed, there is one equally certain; namely, that what are called *ſoils* are powders or maſſes very complex in their mixture and compoſition; and to determine with accuracy the kind of action they exert on vegetables, moſt of the properties of which they modify, it is neceſſary to inquire particularly what is owing to the earth properly ſo called, and what is effected by ſubſtances foreign to the earthy particles mixed with them. The firſt conſtitutes the baſe of the ſoil properly ſpeaking, the ſecond belong more or leſs to the article of manure, which will be the next on which I ſhall treat.

4. Among the ſoils in which vegetables grow, it would be vain to ſeek a pure and iſolated earth. The fineſt, drieſt, moſt acrid ſand, approaching neareſt to ſiliceous earth properly ſo called, is always a mixture of quartz, alumine, and frequently a little calcareous matter. To determine in what manner each earthy ſubſtance contributes to vegetation, or to the ſupport of vegetables, the chemiſts who firſt applied their ſcience to agriculture and vegetable phyſics, particularly examined the manner in which ſeeds comport themſelves in each pure earth chemically prepared; and though it follows from their experiments, that ſeeds germinate very well in arid earths, well waſhed, inſipid,

and deprived of every ſaline particle, provided theſe earths were humectated, it is likewiſe ſufficiently proved, that neither of them excluſively or powerfully favours vegetation. Seeds may be made to germinate alſo in metallic powders or filings, and on ſponges, cotton, tow, &c. moiſtened with water; but in theſe mediums vegetation does not continue long, it never reaches its full term, unleſs with delicate, weak, and ſmall plants, which require but very little ſubſtance for their nouriſhment.

5. From theſe trials, however, it has been concluded, that the ſoil forms no more than a ſimple ſupport for vegetables; that it affords a lodgment and ſtay for the roots; that it merely ſurrounds theſe with the water and nutritious matters of which they have need, and of which it is only the receptacle; that it requires only to be very eaſily permeable by the roots, to retain a ſufficient quantity of water to keep them always moiſt, to be ſufficiently divided to let the air and every part of the light paſs between its molecules, and not to be ſo compact as to compreſs the radical fibrils. It can ſcarcely be doubted, that a ſmall portion of the earth itſelf penetrates the roots, and is conveyed into the interior of vegetables, by the abſorption of which the vegetable organs are capable, and by its ſtate of diviſion, or even of ſolution in water.

6. Bergman, in his diſſertation on *geoponic earths*, infers from a great number of experiments,

ments, that the beſt earth for the production of vegetables is a mixture of two parts of calcareous earth, one part of magneſia, four parts of alumine, and three parts of ſand. All the reſearches of the moderns have taught them, that ſalts contribute nothing to vegetation; that on the contrary there is reaſon to believe them to be always injurious to it: that pure earths alone, or mixtures of them with one another, were not fit for it; and that fertile earths loſe all their properties by the action of fire. Theſe laſt facts have been particularly obſerved by Mr. Giobert, a chemiſt, at Turin.

7. From all the experiments, which have been varied in a thouſand ways, reſpecting the relation that vegetables bear to the ſoils in which they are planted, one uniform, conſtant, and of courſe certain reſult has ariſen; this is, that of all the ſubſtances found in the mixture of earths, that conſtitute a ſoil, calcareous earth contributes moſt certainly to its fertilization. There is nothing equivocal, uncertain, or contradictory in this fact. It is aſcribed to this, that moſt of theſe calcareous ſubſtances retain ſomething of their ancient animal origin, which becomes a ſort of manure. For my own part I have no doubt, that this fertility muſt be attributed to its carbonic acid. Be this as it may, it is ſo true, that calcareous matter is the moſt uſeful of all earthy or ſaline earthy ſubſtances in agriculture, that farmers frequently renew their land with it.

8. It is neceſſary to mention, however, that though calcareous earth is the moſt frequent and moſt uſeful ſubſtance that can be employed for improving land, and on this account marle claims the firſt rank even among manures, the art of improving lands, conſidered in its greateſt latitude, cannot be confined to a ſingle proceſs, but muſt vary according to the nature of the ſoil on which the farmer is to operate. Marle and chalk are certainly ſuitable to a ſtrong and too clayey ground; but land too uniformly calcareous or ſandy may require, on the contrary, clay to give it the binding quality it wants, and the property of not drying too quickly, but retaining the water a little longer than it did before.

ARTICLE VIII.

Of the Influence of Manure on Vegetation.

1. IT has been proved above, that pure and iſolated earths do not directly ſerve for vegetation; that water alone can anſwer the purpoſe ſtrictly ſpeaking, but that it does not furniſh all the principles neceſſary for fertility and the complete growth of plants; ſo that, for inſtance, moſt afford no fruit, or at leaſt their vegetation is feeble. Though it has long been ſuppoſed,

that plants are nouriſhed by means of their leaves, and derive their aliment from the air, ſo that they appear capable of growing by means of water, light, heat, oxigen gas, and the elaſtic fluids that uſually compoſe the atmoſphere, it is equally ſeen, by all the data and experiments of agriculture, that the greater part of the nouriſhment of vegetables is derived from the earth, and that the earth greatly influences their condition, ſtrength, quickneſs of growth, the nature, taſte, and ſmell of their fruits, &c.

2. It has long been obſerved, that the earth, in affording vegetables the principles neceſſary for their growth, is exhauſted at the end of ſome time, and that it is neceſſary to reſtore to it what it has loſt. Hence it has been inferred, that ſomething paſſed from the earth into the plants, and that this portion neceſſary to vegetation was gradually diſſipated, ſo that we were obliged to reſtore it to the ſoil. It is this addition of nutritious and vegetative matter to the earth which is called *manure.* Nature itſelf furniſhes the example of this neceſſity of continually repairing the loſs the ſoil ſuffers from the vegetables that penetrate and cover it: every year it reſtores to it what the plants abſorb by the remains of thoſe which die, accumulate on the ground, putrify there, are decompoſed, and thus form ſucceſſive layers of a ſort of mould, or vegetable earth, in which germes unfold themſelves kindly, and roots imbibe the principle of vegetable nutrition.

3. It is by this natural mechaniſm, that ground crowded with trees and vegetables of different kinds growing every where around them, becomes covered to a greater or leſs depth with vegetable earth, which long ſecures its fertility It is this layer of fertile mould, which men find after clearing ancient foreſts, and in which they ſcatter the ſeeds and germes of various plants, which acquire in it a quick and ſpeedy growth. Thus in a ſucceſſion of ages are formed thoſe lands of inexhauſtible fertility, which man takes from the hands of Nature in the foreſts of America; where he begins by cutting down or conſuming the ancient vegetable inhabitants, before he enters upon the uſeful cultivation of many plants, to which our cold or temperate climates are incapable of affording nouriſhment.

4. The farmer imitates this proceſs of nature, when land appears to him exhauſted of its nutritious juices, by too long or too vigorous vegetation: ſtirring it up with the plough, or ſome other inſtrument, he likewiſe adds to it the remains of vegetable or animal ſubſtances, which are called *manure.* Moſt commonly theſe remains conſiſt of the ſtraw which has been uſed as litter for animals, and which, impregnated with their excrement and urine, is laid in heaps to heat, ferment, putrefy, diminiſh in bulk, and become what is called dung. The leaves of trees heaped up in a ſimilar manner, watered, heated, fermented, ſoftened, and decompoſed, are likewiſe

uſed for the ſame purpoſe. The bones of animals, the horny parts, and even the hardeſt horns, cut into ſhreds or fragments, or ground to powder, are alſo uſed frequently for manure in ſome countries. In ſeveral, human excrements long kept, and ſometimes converted into a dry inodorous matter, known by the name of *poudrette*, is employed for this purpoſe.

5. It is with the ſame deſign, but conducted on a much larger ſcale, and of more immediate utility, that intelligent men, when breaking up large quantities of ground, keep on the exhauſted or merely impoveriſhed land a number of animals, particularly ſheep; which, while they ſtill find on it food ſufficient for their wants, render immediately to the earth, either by the ſolid and liquid excrements which they depoſit on it, or by the perſpirable matter which iſſues from them when they lie down, more than they have borrowed from it. This mode of dunging ground indeed requires a conſiderable capital, as the firſt expenſe is great; but it amply repays the farmer who practiſes it, and whoſe ſpeculation turns entirely, as has been ſeen, on the reciprocal converſion of vegetable matter into animal ſubſtance, and of the latter into the former.

6. The ſcience of phyſics has long been ſilent on the mechaniſm or cauſe of action of manure. Ancient chemiſtry explained it by a theory of ſalts and ſtimulants, which modern diſcoveries have diſmiſſed to the realms of fable and error.

It is particularly in the latter that this theory is placed by modern agricultural experiments, the reſult of which has proved, that real ſalt mixed with the earth injures the production of plants cultivated in it. Pneumato-chemical analyſes have furniſhed more accurate notions of the influence of manure, in teaching us that plants are formed of hidrogen, carbon, oxigen, and ſometimes azote, ſulphur, and phoſphorus, without reckoning lime, ſilex, and pot-aſh. If theſe principles alone exiſt in the ſubſtances of plants, it is evident that they require only theſe for their growth.

7. This reaſon is ſufficient, to lead us to a knowledge of the action of manure. In fact, in the compound ſubſtances which form them we find theſe firſt principles in abundance: hidrogen is contained in them ſo plentifully, that it frequently eſcapes in the form of gas during their decompoſition. The carbon ſhows itſelf in them by the black colour, which dung aſſumes when completely rotten, and in the hue of the mould into which it is changed. The liquor that drains from dunghills, if we abſtract from it in imagination the ammonia, and the animal ſubſtances which are mixed with it as foreign matter, is for the moſt part nothing but water holding in ſolution carbon, which we may ſee ſubſide to the bottom by keeping it ſome time. Carbonic acid gas is perpetually flying off from mould; ſo that nothing is wanting to this compound, neceſſary to ſupply nouriſhment to

plants; but on the contrary, the nutritious matter they afford is ſo abundant, that it is eaſy hence to explain how vegetation is ſo ſtrong in it, and the growth of plants ſo rapid.

8. We may even judge from this, and from comparing the influence of the ſoil with that of the air for the quickneſs of the growth of plants, and the vigour of vegetation, that the ſoil contributes much to it through the means of the manure with which it is covered, and that roots ſuck up with great energy the different alimentary matters in a liquid form, while very little paſſes through the leaves, which are rather organs of perſpiration. It is no leſs accurately proved to the obſerving eye, that water is the common vehicle of earths, carbonic acid, carbon, and hidrogen, almoſt iſolated, which are conveyed into the organs of plants: that for this reaſon its preſence is ſo neceſſary in the earth into which roots penetrate, and that in this it acts the double part of promoting the flow and ſucceſſive decompoſition of the vegetable ſubſtances that form manure, with a ſort of diſſection of their parts, and of conveying theſe into the abſorbent veſſels of plants.

9. Manures, or the organic matters which form them by the mixture of their particles with thoſe of earths, properly ſo called, have alſo another effect beſide that of furniſhing the roots of plants with aliment: or rather this principal effect is accompanied by another

auxiliary, it is true, but not leſs uſeful. Theſe manures we know undergo a continual fermentation, which attenuates, divides, and decompoſes them. This action cannot take place without an increaſe of temperature, and the heat thus produced muſt greatly promote vegetation. The earths, very rich in nutritious principles, which are employed in the beds and hot-houſes of kitchen and botanic gardens, earths which contain much horſe-dung, or tan, are ſo hot, that on thruſting the hand into them, we find a great difference between the temperature without this ſolid medium, and that within it. Accordingly, many ſeeds are brought to germinate in them, which will not in our natural ſoil; and a great many plants are cultivated in them, which would languiſh or die in common ground. Farmers know, that by uſing dung not properly rotted, or too little fermented, it occaſions a too haſty vegetation, dangerous in our climates, where cold ſo eaſily affects or kills delicate plants raiſed too ſoon. There is no other reaſon for their carefully avoiding the uſe of too freſh and too ſtrong dung, but the violent heat it occaſions in the earth by the fermentation it undergoes: and thus with good cauſe they term it *too hot*. It is ſo true that manures ferment ſtrongly, that at a certain period we obtain from them alkaline, calcareous, and ammoniacal acetites by lixiviation, and a ſtrong ſmell of vinegar is emitted by them, if we pour on them more potent acids.

10. There is ſtill one more effect to be obſerved in manures, which was diſcovered by Dr. Ingenhouſz: the power which they appear to exerciſe on the atmoſphere, the abſorption of its oxigen which they effect, and the tranſmiſſion of it from them into the abſorbent veſſels of the roots, which unqueſtionably takes place. If a vegetable mould be expoſed to the contact of air in a cloſe apparatus, when we examine this air ſome time after, we ſhall find it deprived of a portion of its oxigen. This privation ſoon proceeds to a total abſence of it, ſo that it is one of the ſureſt means at preſent of procuring atmoſpheric azote gas. Though Mr. Humboldt believes that he has obſerved this abſorbent property in pure earths, and particularly in alumine and magneſia, there is ſcarce a doubt but it muſt be much more powerful in thoſe which are mixed with vegetable matters; and that theſe, conſtituting manure, act with regard to the oxigen of the atmoſphere as a ſort of combuſtibles that have great tendency to oxide, and from which roots take this principle, when they have been conveyed into their veſſels by means of water.

11. It cannot be queſtioned that this oxigen, precipitated from the air, and fixed in manures, acts a more or leſs important part in vegetation, when it is conſidered as calculated to convert the carbon of manures into carbonic acid, ſo beneficial to the growth of plants when water offers it to them in a diſſolved and fluid

ſtate; and when, on the other hand, we obſerve the effect produced on the nutrition of vegetables by lixivia of oxigenated muriatic acid mixed with the earth into which roots penetrate. Citizen Pajot-Deſcharmes, who ſucceſsfully applies the phenomena of chemiſtry to manufacturing proceſſes, has remarked, that lixivia of oxigenated muriatic acid, extremely dilute it is true, and which had already been employed in ſeveral operations, being thrown on the earth of a garden, ſingularly promoted the growth of the vegetables that occupied the ſpots thus watered. On comparing this obſervation with the facts obſerved by Dr. Ingenhouſz and Mr. Humboldt, we ſee clearly, that the abſorption of oxigen is one of the moſt fecundating and moſt uſeful effects of manure.

12. From theſe data, ſo much enlarged and ſo well explained by modern chemical ſcience, ariſes a knowledge of the effects produced by tilling and breaking the earth, ſo much recommended by all able huſbandmen: we ſee, that by ſtirring the earth to a certain depth, it is not only rendered lighter, ſofter, more divided, more permeable, and the weeds and inſects which live in it and exhauſt it, are deſtroyed; but the manure deeply buried is brought to the ſurface; this valuable aliment is diſtributed equally to all parts where the roots will creep; and what the preceding vegetation had taken from the exhauſted portions is reſtored to them. By thus renewing all the ſurfaces of the mould,

tillage expoſes to the air the matter that tends to deoxigenate it; and by increaſing the abſorption of oxigen by the ſoil, it augments its vegetative power in a degree proportionate to the renovation of ſurface: in a word, it increaſes this concealed combuſtion in which great part of the influence of the air conſiſts, which was formerly explained in ſuch a vague manner by the ſalts that were ſuppoſed to be depoſited in the earth; at a period from which we are not yet far diſtant, when phyſics, in a ſtate of little advancement, and contenting itſelf with thoſe hypothetic gleams, which then conſtituted the whole of its theory, had not acquired that accurate knowledge of the nature of the air, and the compoſition of vegetable matter, which it poſſeſſes at preſent.

ARTICLE IX.

Of the Functions of Vegetables, or the Phenomena which they exhibit during their Life, and of the Mechaniſm by which the conſtituent or component Parts are formed.

1. WHAT has been ſaid in the eight preceding articles preſents a ſeries of facts reſpecting all the materials, that ſerve for the formation of vegetables, which actually change

into their proper ſubſtance, and which they are capable of converting into ternary or quaternary compounds, and of appropriating ſo as to increaſe their own bulk. It remains for me to give a ſketch of the manner in which theſe different elements, admitted into the veſſels of plants, are there decompoſed, or combined in a new order, by what powers they are converted into the materials of vegetables, what phenomena accompany and indicate this converſion; in a word, in what vegetable life conſiſts: for it is very evident, that a germe being given, the life it receives, and which continues till all the phenomena that conſtitute vegetation have been completely exerted, conſiſts wholly in this appropriation, this converſion, this complicated combination, which the primary materials undergo after they are received into the veſſels of plants.

2. This beautiful mechaniſm, which is called *vegetation*, has at all times excited the admiration of philoſophers, and they have endeavoured to form a conception of its cauſes, and aſcertain their effects; but their endeavours have not yet been crowned with a ſucceſs anſwerable to their wiſhes. Modern chemiſtry has revived their hopes, new paths have been ſtruck out by it, and the ſketch I am about to trace will ſhow, that the new career opened by its means, and its method, though yet little followed, have already removed ſeveral difficulties hitherto deemed inſurmountable. It is neceſſary to

conceive in the firſt place, that the phenomena of vegetable life ſo manifeſtly belong to a chemical power, that no ſcience but that can explain its mechaniſm. This truth is included in the enunciation of the problem of vegetation. In reality it may be conſidered as the only queſtion, to determine how vegetable machines convert the principles they abſorb as aliments into what we have called their materials.

3. There is no room to doubt, that plants form theſe compounds in executing the functions, which taken together, truly repreſent the circle of their life: we muſt inquire then wherein theſe functions conſiſt, and examine their relation to the formation of vegetable compounds. The functions of vegetables are either internal, ſometimes not very perceptible, ſo that their exiſtence is known, and their phenomena ſtudied, only by the help of experiments and methods which in ſome degree aſſiſt the weakneſs of our organs, or they are external, come under the cognizance of our ſenſes, and diſplay themſelves by phenomena, or ſigns more or leſs ſtriking, more or leſs eaſy to be perceived.

Of theſe functions ſome are exerciſed during the whole life of the plant: others are periodical, or ſhow themſelves only at different ages of the plant, which are moſt commonly even determined by them. We find in ſucceſſion, and in the order in which they are mentioned,

a. The motion of the ſap, and of the fluids;
b. Their ſecretion;
c. Irritability, or the movement of the ſolids;
d. Nutrition;
e. The flowing of different juices;
f. Vegetable tranſpirations.
g. The direction of the parts of plants:
h. The periodical repoſe, or ſleep of plants;
i. The germination of plants:
k. Their foliation;
l. Their flowering;
m. Their fructification.

Some phyſiologiſts have reckoned a greater number of phenomena among the functions of plants, becauſe they have conſidered them with the eye of the agriculturiſt, &c.; but the twelve that I have mentioned compriſe in reality all that paſſes in the circle of vegetation, and every thing likewiſe that enters into the relation I mean to point out between the chemical analyſis of vegetables and the life of plants.

I ſhall proceed briefly to run through each of theſe functions, of which I have already ſaid a few words at the commencement of this ſection, but I deſcribed them only as phenonema of vegetable life; and I have here to conſider them in their mechaniſm and intimate reſults, to ſhow, that they either ariſe from chemical attractions, or lead to them.

A. *Motion of the Sap.*

4. The motion of the ſap takes place from the root toward the ſummit of the ſtem; and this fluid, manifeſtly formed by the water, which the roots have abſorbed, and which holds in ſolution the materials of the earth or of the ſoil, undergoes during this very motion certain chemical changes. With the ſap there circulates a more or leſs conſiderable portion of carbonic acid, which, by the internal heat of the plant, is frequently diſengaged from the water, and moves in the air-veſſels ſo as to iſſue with a perceptible ebullition through openings or auger-holes made in a tree. The exceſs of this acid eſcapes by vegetable tranſpiration: a great part is decompoſed, and furniſhes carbon, which unites with the hidrogen and oxigen; hence the mucilages, the ſaccharine ſubſtance, the tannin, the acids diſſolved in the ſap; hence too the extractive matter, which ſometimes colours it, and renders it always liable to become coloured by the oxigen of the atmoſphere. Frequently this nutritious juice carries with it ſalts, and even acetites, which the water has taken from the manure uſed on the ground, as well as earths and carbon in a ſtate of minute diviſion, proceeding from the ſame ſource.

5. Many hypotheſes have been framed, to explain the mechaniſm of this aſcent of the

ſap. The following is the moſt ſimple, with the greateſt appearance of probability. The warmth of ſpring, which excites it, dilates plants, and recalls their life, which the winter's cold had benumbed. The diluted veſſels have a vacuum produced in them, which cauſes the aſcent of the fluid that remained in the ſtem, and was collected in the roots, and in ſucceſſion that which moiſtens the earth, in which the roots are embedded. This firſt movement of vegetation does not ſlacken or ſtop, but with the diminution of the temperature of the atmoſphere to a few degrees only above and below 0. Whether the ſap re-deſcend toward the earth by the cortical layers, and whether this paſſage be open to it only during the night, are problems that remain to be ſolved: though they have been conſidered as decided by cicatrices and the ſwellings that grafts form above the ſtock, and by the iſſuing of the ſap from the upper end of a notch. The ſap, carried at firſt toward the centre of the ſtem, ſpreads laterally and along the prolongations of the pith, to reach the external layers, where the dilatations and vacuums are greater. The lighteſt, moſt fluid, moſt rarefied portion of the ſap, and the moſt remote from the roots, after it has depoſited the matter capable of becoming ſolid, which it held in ſolution, iſſues through the leaves in vapour or in drops. We learn from Hales, that the power of aſcent in the ſap of the vine reaches to thirteen metres, conſequently higher than water is ſupported by the weight of the atmoſphere.

6. We readily conceive, that this aſcending and lateral motion of the ſap, and of the carbonic acid gas, or of the air with which it may equally be accompanied, muſt exiſt in the different fluids of vegetables, which are known by the name of their *proper juices ;* but that this ſecond ſort of motion is but a ſlow and limited change of place, compared with that of the ſap, on account of the leſs abundance of theſe juices, of their diſtribution in particular orders of veſſels, of their adheſion which is proportional to their greater conſiſtence, and of their more intimate propenſity to grow thick, concrete, and become ſolid. Theſe juices have ſcarcely any thing more than the ſlight motion, which the ſap communicates to them, and is produced by its lateral preſſure on them. Thus we ſee it would be an abuſe of words, and an entire confuſion of ideas, to compare theſe movements of vegetable juices with the circulation of the blood in animals.

B. *Secretion.*

7. WHEN the ſap, the primary nutricious fluid of vegetables, water loaded with all the matters which it has taken from the ſoil more or leſs manured, has arrived at the different parts of the vegetable, which envelope the common veſſels, it diſtributes itſelf to the different orders

of its texture, which it traverſes, or with which it is in contact: and it depoſits in them the ſubſtance proper for enlarging the growth of each, or for repairing the continual loſſes it ſuſtains. In this ſeparation, in this diviſion of the different materials, all contained in the ſap, but appropriate to each of the veſicular organs in which they are depoſited, conſiſts ſecretion, the exiſtence of which in the phenomena of vegetation cannot be overlooked, or its influence in them denied.

8. Undoubtedly we do not yet well know what the mechaniſm is, by which the ſap, that appears in the veſſels as a homogeneous fluid, yields different juices to different parts, and is converted into matters frequently the reverſe of each other. The fact however being acknowledged as certain, it appears, that we can admit as the cauſe of this converſion nothing but a true chemical change, governed unqueſtionably by the ſtructure of each order of cells, their diſtance from the centre of the tree, their propinquity to the ſurface expoſed to the air, and the difference of temperature. We may form ſome idea of this chemical function, by ſeeing all the homogeneous vegetable ſubſtances, when operated upon in the laboratory by fire, by the nitric, oxigenated, muriatic, and ſulphuric acids, and by cauſtic alkalis, ſeparated into two or three new ſubſtances different from each other, namely, into two acids, into oleaginous ſubſtances, &c. I have no doubt but a

chemical action, perfectly ſimilar to that I have mentioned, takes place in the operation of vegetable ſecretion. The carbonic acid, oxigen gas, and the influence of light and caloric, to which the ſap is more or leſs expoſed in the little bladders or cells where it ſtays, are probably the agents in theſe chemical operations, the whole of which are compriſed in the function of ſecretion.

9. It is thus I conceive the ſucceſſive formation of all the proper juices, the gummy, ſaccharine, oily, acerb, colouring, and acid; as well as that of the ſolid parts to which they give birth by their concretion, as the woody ſubſtance, the fecula, the tannin, the reſins, the concrete ſalts, &c. Thus by the action of chemical powers, which ſeize on different part of the ſap, are compoſed the ſubſtances I have examined under the name of *immediate materials of vegetables:* thus are depoſited in the roots, ſtems, leaves, flowers, fruits, and ſeeds, the different matters that form them. We may ſee a ſlight ſketch of this in the ſpontaneous alterations the ſap undergoes, as it exudes naturally in tears, or is extracted by boring holes in the trunks of trees, when expoſed to the air, the contact of which colours it, renders it turbid, precipitates it, alcoholizes it, ſours it, &c.

C. *Irritability.*

10. Little connection appears at firſt between the function termed *vegetable irritability*, and the chemical properties of which I here eſtabliſh the exiſtence in the cauſes and phenomena of vegetation. We are indebted to modern philoſophers for the admiſſion of vegetable irritability. On ſeeing the leaves of the ſenſitive plant ſo moveable at the ſlighteſt touch, the ſudden motions of the flower of *dionæa muſcipula*, the contractile drooping of the foliage of the *Ledyſarum gyrans*, the almoſt convulſive contraction of the ſtamens of the common berberry, and of the dwarf ciſtus when irritated by a pointed inſtrument, and ſo many other motions which ſeem to contract the muſcles of the parts of plants in which they are obſerved, the moderns have imagined, that an irritable power, ſimilar to that of the organs of muſcular motion in animals, exiſts in theſe parts.

11. Mr. Humboldt, while carefully ſtudying this beautiful vegetable phenomenon, has inquired into its connection with ſome chemical power or cauſe: and he has found ſubſtances that increaſe it, that renew it when it is weakened, and others that diminiſh it, or cauſe it to ceaſe. In general, oxigenated ſubſtances that eaſily part with their oxigen appear apt to

produce the former of theſe effects, and the latter is owing to the abſtraction of oxigen from the vegetable. It is thus, according to him, that the oxigenated muriatic acid favours and accelerates vegetation as well as germination, in which he admits the irritability of the germe as the principal cauſe. It is known, too, that light and caloric ſtrengthen this function; and it is aſſerted that opium deſtroys it, by the application either of its ſolution or of its fumes. Such are the ſlight data which begin to ſhow ſome analogy between the vegetable and animal irritable powers. Mr. Humboldt has drawn from it an inference of uſe in agriculture, in ſhowing by experiment, that ſeeds which do not commonly germinate in our climates or in our hot-houſes, and which of courſe we cannot raiſe for our gardens, or hope to naturalize in our fields, become capable of germinating when immerſed for ſome days in a weak lixivium of oxigenated muriatic acid. This intereſting diſcovery has already been turned to advantage in ſeveral botanic gardens.

D. *Nutrition.*

12. If the reader have clearly comprehended the firſt chemical facts which I have deſcribed reſpecting the changes which the ſap undergoes in its movements, and the ſeries of ſecretions to which it gives riſe, it will not be difficult

for me to prove, that vegetable nutrition and the growth of plants are merely the reſult of chemical combinations, or to ſhow him both are accompliſhed. In the firſt place it muſt be obſerved, that the greater part of the water, which conſtitutes the ſap, eſcapes out of the plant; but while it thus flies off, it leaves in it the different matters capable of becoming ſolid, which it held in ſolution. If to this well-eſtabliſhed fact we add, that a portion of the water appears to be decompoſed in the plant, particularly in its leaves acted on by the ſolar rays, that the carbonic acid is equally decompoſed in the organs of vegetables, that in this double decompoſition, the greater part of the oxigen that oxides the firſt of theſe ſubſtances and acidifies the ſecond, eſcapes out of the plants, and as the reſult of this double effect we find hidrogen and carbon, which unite ſimultaneouſly with a greater or leſs proportion of oxigen, and which, with the earths, ſalts, &c. carried by the water, may form all the ſolid matters that conſtitute the ſubſtance of vegetables.

13. Among the matters which we find in all vegetable ſubſtances, it appears that their particular compoſition is determined by the particular place they occupy. Thus the ſaccharine matter is formed almoſt every where; the woody ſubſtance in the ſtalks, the fecula in the tuberoſe roots, the medullary bladders, and the cotyledons of the ſeeds, the fixed oil almoſt excluſively in the latter, the tannin in the

woody layers, the mucilage in the cortical layers and under the coverings of the ſeeds, the acids in the leaves, and in the pulp of fruits, &c. We know not yet, it is true, by what chemical law each of theſe matters aſſumes its peculiar compoſition in this or that region, in this or that organ of vegetables; but it is very natural, that in the commencement of a ſcience we ſhould have but few ideas concerning an object ſo new. I have already ſaid above, that every kind of organ having a different texture, its poſition with reſpect to the ſurrounding air, its diſtance from the centre or nearneſs to it, its temperature, the action of the air and carbonic acid gas within, the place even which the ſap occupies relatively to the point from which it proceeded, and to the alterations it has already undergone ſince it was firſt formed, furniſh the modern theory with ſufficient data, to allow it at leaſt to look forward to the period, when poſſeſſed of experiments and reſearches founded on the new views, it ſuggeſts, it will be capable of giving a ſimple and luminous explanation of what appears yet a myſtery.

14. Though the mechaniſm of the particular formation of the different materials of vegetables be ſtill covered with a thick veil, chemiſtry already offers ſome tolerably accurate reſults reſpecting the growth and nutrition of plants, owing to the ſucceſſive changes of theſe materials. It no longer contents itſelf, as heretofore,

fore, with repreſenting this growth under the vague and almoſt unmeaning aſpect of the condènſation and ſolidification of fluids; it ſhows the ſap, become a proper juice of the plant carried by the prolongations of the pith even to the inſide of the bark, increaſe on the one hand the thickneſs of the cortical layers by ſucceſſive additions of matter condenſing there; and on the other hand conſolidate the cortical layers that were formed the laſt, by means of their viſcoſity, denſity, and vegetable plaſticity, which it has acquired. It proves, that this conſolidation is owing to the ſlightly hidrogenated particles of the carbon being brought cloſer together, owing to the fixation of the oxigen. It ſhows that a variation in the proportion of one or other of theſe principles, and of the earth and foſſil ſalts which accompany them, forms tannin, the colouring matter, and the extractive matter, at the ſame time with the wood. It points out the mucous ſubſtance, the ſaccharine matter, the amylaceous fecula, diluted at firſt in an aqueous fluid, which keeps them in the ſtate of mucilage, of fluid honey, of milk more or leſs thick, acquiring their ſolid form by the evaporation of the water, owing to the air, or to the ſuction of numerous mouths, which convey the ſuperfluous aquoſity to the interior and tranſpiratory pores with which the leaves are perforated. It teaches us that the ſuberal ſubſtance, which forms the inorganic and frequently papyraceous texture of the bark, acquires its dry fragility, or elaſtic ſuppleneſs and ſemi-tranſparency, by the exſiccation of a viſcous juice ſpread in thin coats over the exterior part of the vegetable, and modified by the contact of the air, and the action of caloric and light. It explains how a volatile or a fixed oil expelled out of plants, and thus having its ſurface expoſed to the air, becomes the firſt a reſin by loſing hidrogen, the ſecond a wax by abſorbing oxigen. In a word, it begins to penetrate much farther into the explanation of the different phenomena relating to the growth and nutrition of plants, than we could have dared to hope a few years ago; and it preſages what it may ſome day accompliſh in this elegant and uſeful branch of human knowledge.

E. *Efflux or Flow.*

15. I employ the word *flow,* to expreſs the ſpontaneous iſſue of fluids from the ſurfaces of vegetables. This is properly a vegetable ſecretion. Thus we ſee the very liquid and almoſt aqueous ſap flow from the extremities of the branches and from the joints of the vine, the birch, &c. the inſipid and gummy mucilage from fiſſures in the bark and in the ſtalks of the fruit of the almond, peach, apricot, plumb, and all other trees that bear fruits with ſtones in them; the volatile oily juice or reſinous eſſence from firs, larches, and all the evergreen and reſinous trees; the

honeyed and ſaccharine juice from the bottom of the petals and in the nectaries of a great number of flowers, and from the upper ſurface of the leaves of the aſh, elm, and linden. Some glutinous juices, gummy-reſinous, or of the nature of glue, flow likewiſe, and ſpread in glutinous coats over the youg ſhoots of the *acacia viſcoſa*, &c. Finally, the fixed oil itſelf exudes in little ſubtle drops, and appears on the ſurface of ſeveral fruits, particularly thoſe of the myricas, crotons, and ſome trees of the laurus family: in the air it gradually aſſumes the characters of wax.

16. In theſe different kinds of flowing we ſeeing manifeſtly the product of too great fulneſs, of a plethora which ſwells and tears the veſſels, or which diſtends and opens the cells, or which iſſues from the extremities of the full ducts: it is an evacuation occaſioned by the ſuper-abundance of the alimentary ſap, or of the proper juices of the plant. In the latter caſe it anſwers the place of a certain morbid and almoſt critical flux, which is of great utility to the plants in which it occurs. The reſult of this ſecretion is the iſſue of ſome of the immediate materials of vegetables, ſimilar to thoſe that are extracted either by mechanical means, or by chemical proceſſes. It ſhows that art, in the operations it employs to procure theſe matters, makes them undergo no alteration, obtains them ſuch as they exiſted in the

plant, and may depend as much on the products it acquires, as on thoſe which nature furniſhes.

17. I have elſewhere ſhown, that man imitates this proceſs of nature by wounding or piercing plants and trees, and thus increaſing the flow of matters, which are of great uſe by their properties in the arts. Thus are procured the ſaccharine juice of the maple, the ſugar-cane, the palm-tree, the reſinous oil of pines and firs, the gummy-reſinous juice of a number of plants, particularly the umbelliferous, the extracto-reſinous juice of the poppy, the euphorbiums, &c. It is by a ſimilar mechaniſm, too, that the puncture of a great number of inſects, which raiſe up the epidermis of the leaves, petioles, and ſtems of ſeveral trees, occaſions an artificial cavity, which is filled with many different juices, and particularly with the aſtringent and very concreſcible fluid from which we obtain the gallic acid, &c. Frequently, indeed, in the latter caſe, an animal matter afforded by the inſects, that of their excuræ, eggs, and excrements, mixes with the vegetable ſubſtance, and modifies the characters as well as the chemical properties of the parenchyma of the galls produced by theſe punctures.

F. *Tranſpiration.*

18. Though there are yet many facts to be verified or diſcovered reſpecting the tranſpiration of vegetables, it is one of their functions

that is beſt known, and that throws the moſt light on vegetation. Woodward, Hales, Bonnet, Duhamel, St. Martin of Vienna, and Citizen Sennebier of Geneva, have ſtudied it with particular care, and with very diſtinguiſhed ſagacity. Their reſults, without having that preciſe ſimilarity which it is impoſſible to find in ſuch a delicate part of phyſics, are yet ſufficiently alike on the whole, to leave no reaſonable doubt of the truths which theſe authors have recorded in their works. By giving an account of the principal reſults we ſhall ſhow, that they are well adapted to agree with the data of modern chemiſtry, which furniſhes a luminous explanation of them.

19. It has long been known, that if a living plant, or a branch of one, be encloſed under a receiver, the ſides of the veſſel will be covered with little drops of an aqueous vapour, while the plant loſes a portion of its weight. A plant deprived of life, indeed, exhibits part of this phenomenon, but with two differences: the firſt is, that in proportion as the water iſſues in vapour from its ſurface, it dries and withers, while the living plant retains its life and freſhneſs: the ſecond, that the latter continues to furniſh this aqueous product, while the dead vegetable is very ſpeedily exhauſted, and affords it only for a time, which is terminated by its becoming dry. Thus we ſee, that in the latter caſe it is a ſimple evaporation, owing to a remnant of life, and more particularly to the

ſolvent action of the ſurrounding air: while in the living vegetable there is an internal action that ſupports this function, to which the external air contributes only but for one part of the phenomena, which will be ſoon appreciated.

20. The tranſpiration of a vegetable may be meaſured, and its products collected, if the tranſpiring plant be incloſed in a glaſs veſſel. Thus Hales found that a ſun-flower, near a metre in height, loſt near a kilogramme of tranſpiration in twelve hours, and tranſpired ſeventeen times as much as a man. The moiſture of the earth in which the plant grows contributes much to the ſupport of this function: the more water the earth contains, the more iſſues from the ſurface of the vegetable. The extent of this ſurface too has much influence on it: and as it is by its leaves alone, that this tranſpiration takes place, it is evident, that the ſpace they occupy ſhould be meaſured, to compare its proportion with the quantity of the evacuation. The meaſures of theſe two will always be found in a direct ratio to each other. If the leaves of a vegetable therefore be plucked off, its vegetation will be extremely diminiſhed, by ſtopping its tranſpiration, and this may be carried ſo far as to kill the plant. We ſee here, that the principal uſe of the leaves is the exerciſe of this function, and that their multiplicity ſhows the importance of tranſpiration to a vegetable.

21. There is a direct relation between the tranſpiration of a plant, and the ſuction of its roots. One of theſe phenomena follows the other ſo exactly, that there is reaſon to preſume that they are mutually dependant on each other, and that the mechaniſm of the motion of the ſap in plants very regularly follows this mutual relation of the two functions. It is tranſpiration, which carrying off into the air, under the form of vapour, the greater part of the water that flows from the trunk into the boughs, from thoſe into the branches, and from the branches into the expanſion of the leaves, is continually emptying the veſſels of the plant, and inceſſantly drawing into it freſh fluid, to replace what is evaporated. Hales found by his ingenious experiments, that the ſurface of the leaves being eleven times as much as that of the roots, the water muſt flow eleven times as quick in the roots as in the leaves.

22. The contact of light, and that of warm air, are neceſſary to keep up vegetable tranſpiration. If the former be intercepted, according to the experiments of Citizen Sennebier, by a piece of linen or paper, the tranſpiration is conſiderably diminiſhed: warm and dry winds ſingularly promote it: during the night it ſcarcely takes place. It is even found, that in the night plants increaſe in weight, and imbibe the water precipitated from the atmoſphere. It is moſt powerful in the ſpring, and at the beginning of ſummer. In autumn the leaves

becoming hard, dry, and ready to fall, no longer exerciſe this function: and at this period too its utility is leaſt eſſential, ſince the plant has by this time fulfilled at leaſt its annual deſtination.

23. On comparing the quantity of water which iſſues by tranſpiration with what enters by the roots, we find very little is left behind in the plant: yet the portion that remains is ſufficient for its nouriſhment, and diſtributes itſelf, either by becoming fixed without decompoſition in the immediate materials which it dilutes, or by decompoſing itſelf ſo as to furniſh the hidrogen neceſſary for the compoſition of theſe materials, particularly the oily juices, and the oxigen proper for converting the greater part of theſe materials to the ſtate of oxides or acids. A third uſe of this water in the portion that evaporates is, to leave in the vegetables through which it paſſes the greater part of the earths, ſalts, and different matters, which it conveys from manures into the interior parts of plants: for we may conceive, that, as it eſcapes in the form of vapour, it comports itſelf with regard to the principles it held in ſolution, preciſely as the water that evaporates in chemical proceſſes.

24. The water which iſſues in vapour from the ſurface of leaves. and which forms a part of their tranſpiration, is not preciſely pure water, as is teſtified by the ſmell of the plants, which it carries out of their texture. Citizen Sennebier ſatisfied himſelf by collecting ſeveral

kilogrammes

kilogrammes in ſuitable apparatuſes, and evaporating what he thus collected, that it contained ſome particles of extracto-reſinous matter, of carbonate of lime, and of ſulphate of lime; and he detected theſe four ſubſtances by the ſucceſſive action of water, alcohol, and acids, on the reſiduum left by his evaporation. It appears, too, that a ſmall portion of ſaccharine or honey matter is carried away by this water of tranſpiration; and that to this ſmall portion is owing that ſlight, greyiſh, ſweet coat, which covers leaves after great tranſpiration, and which is known by the name of *honey-dew*. Sometimes it is ſo copious, that it forms a duſt in the air round trees that have experienced this exceſſive tranſpiration in the great heats at the commencement of ſummer.

25. Mr. Hedwig, in his cryptogamic phyſiology, has deſcribed the veſſels of the leaves which afford a paſſage to the tranſpiration. They are placed under the epidermis of the leaves, and there form a net-work, the meſhes of which are very viſible, when the moiſt epidermis is examined with a microſcope. He thinks that ſeveral of theſe veſſels, to the number of four or five, open into each round or oval pore, with which he aſſerts the epidermis is perforated. But Citizen Sauſſure, who has examined the epidermis of leaves with great minuteneſs, was never able to perceive the pores mentioned by Mr. Hedwig. There is reaſon to believe, that, inſtead of having holes, the epidermis dips into the cavi-

ties of the tranſpiratory veſſels. With a good lens we may ſee pretty diſtinctly the extremities of theſe veſſels, which form little prominences, or a kind of circular tubercles, on the upper ſurface of leaves.

26. The tranſpiration or inviſible vapour, which iſſues from the leaves, and forms ſuch a conſiderable evacuation or excretion of vegetables, does not conſiſt ſolely in the water of which I have hitherto been ſpeaking. Part of this vapour conſiſts of oxigen gas, ariſing evidently either from water, or from carbonic acid, or perhaps from both together, decompoſed in the plant. The iſſue of this gas is one of the chief requiſites of the mechaniſm of vegetation: it announces, and no doubt produces, the health and vigour of plants. It diffuſes throughout the atmoſphere, which it perpetually renovates, the portion of oxigen gas, deſtined inceſſantly to compenſate what is abſorbed in the numerous combuſtions that take place in the ſurface of the globe. It is particularly the iſſue of this gas, united perhaps with the watery vapour of tranſpiration, that requires the contact of light already mentioned above as ſo favourable to tranſpiration. At the ſame time there iſſues from plants, or at leaſt is formed immediately on their tranſpiring ſurface, a pretty conſiderable quantity of carbonic acid gas. It may be obſerved here, that theſe three materials of vegetable tranſpiration, water, carbonic acid, and oxigen gas, are of a nature to be abſorbed

by the earth: ſo that here we find one of thoſe continual circulations, which, huſbanding the primary materials neceſſary for complicated compoſitions, diſplay that wiſe and rich economy of nature, which excites our admiration in ſo many inſtances while we ſtudy her phenomena.

G. *Direction.*

27. THOUGH the phenomenon, which with many modern naturaliſts I here call *direction*, be rather one of the reſults of a function than a real function itſelf, and its ſource or cauſe is yet ſo little known, though it is extremely important to eſtabliſh its exiſtence and effects, yet we ought to treat it as if it conſtituted a function altogether, more particularly as we know not to what general function to refer it. By direction I mean that property, or living power, by which each part of the vegetable, conformably to a particular law, follows a courſe, or directs itſelf, to the nature, reſpective ſituation, or wants, of each of theſe parts. Thus it has been obſerved, that the radicle, after iſſuing from the germinated ſeed, always directs its courſe to the earth, and the plumule to the air; that the branches ſpread and riſe to enjoy the contact of air and light; that the leaves place themſelves ſo as to occupy all a particular place in the atmoſphere, ſo that their ſhining

ſurface is uppermoſt, and their rougher ſurface downward; that flowers turn toward the light and the ſun; that the young branches or twigs bend toward the water, &c.

28. This direction is ſo conſtant, and ſo neceſſary to vegetables, that the parts exhibiting it ſurmount all the obſtacles oppoſed to them, as the experiments of Duhamel, Bonnet, and Citizen Sennebier, have proved. Seeds placed in appearance moſt unfavourably, ſo that the radicle muſt come out at the top, and the plumes at bottom, ſhow themſelves at the end of a few days, the former bending down to reach the earth, the latter riſing up to get into the air. Plants bent at firſt toward the light, and afterward turned the contrary way, will ſoon change their direction: branches bent toward the earth by means of weights or cords, will ſtraighten themſelves, and riſe upward again. Leaves turned, and kept inverted on their footſtalks, reſume of themſelves their primitive poſition; and the reſtraint impoſed by art on all theſe parts is ſoon deſtroyed by the natural power, which tends to direct each to its reſpective poſition, which is peculiar to it.

29. Many hypotheſes to aſſign a cauſe for this movement have been invented and publiſhed. To explain it, ſome phyſiologiſts have admitted a kind of ſenſibility in the organs of plants, though the irritability already mentioned is the moſt that can be aſcribed to them. But it is neceſſary likewiſe to admit a cauſe, a ſtimulant

producing this effect: and this has been ſought in the action of water, air, light, heat, the ſun, and a certain relation between theſe and each of the parts of a vegetable. Unqueſtionably theſe ſubſtances have a direct influence, which cannot be controverted, on the direction taken by the different parts of plants; ſince we ſee this direction follows the contact or preſence of each of theſe external ſubſtances. But how do they act to produce this effect? On what organ do they make an impreſſion? What changes do they produce in it, and how are the changes effected from which this or that direction ariſes?

30 We do not find a ſufficient cauſe for theſe effects either in the imbibition of water and the dilatation which enſues from it, or in the deſiccation and evaporation effected more powerfully on one point than on another, or in a ſuppoſed attraction between ſuch an organ and ſuch a ſubſtance toward which it bends or turns itſelf. But on conſidering that all direction whatever of the parts of a vegetable is the conſequence of a motion, that this always ſuppoſes the ſhortening of ſome fibres at the ſame time as thoſe oppoſite to them are dilated, we ſhall perceive, that there is a ſtimulant action, which ſingularly approaches to what is obſerved in the irritability of animals; but that it differs in this, that its effect is permanent, and leaves the vegetable part in a conſtant ſtate of contraction, which becomes a ſort of habit, and the conſtant poſition of each of theſe parts. We can yet

find nothing that has more probability than this explanation.

H. *Sleep.*

31. THERE are two kinds of ſleep in plants: one, in certain reſpects ſimilar to that of animals, takes place during the night, and returns periodically every twenty-four hours: the other longer, permanent, takes place during a whole ſeaſon, that of winter, and is termed *hibernation.* It is ſuppoſed, that during the night all plants experience ſome change, that they are not in the ſame ſtate as during the day, and we may judge of this from ſome in which the leaves are folded one upon another, often approached or brought cloſe to the ſtalk, and the flowers cloſed. It is commonly ſuppoſed, that the abſence of light, of the return of which theſe plants appear to be ſenſible by the diſplay of their leaves and expanſion of their flowers, is the cauſe of this kind of contraction; and that its preſence produces the evaporation of a fluid, to which we muſt aſcribe a kind of exhauſted ſtate, whence ſleep ariſes.

32. We may doubt the truth of the ſame effect being produced in all plants, or that they experience a ſleep ſimilar to what is obſerved in the ſenſitive plant; but it appears certain that in all the functions which they exerciſe during the day undergo modifications and differences during the night, which con-

ſtitute in them that ſtate which is conſidered as ſleep. Thus the tranſpiration and iſſue of water and gas through the leaves are ſtopped during the night; the ſuction by the roots is greatly diminiſhed or totally ſuppreſſed; and plants, ſo far from loſing weight, increaſe it a little, either by imbibing water precipitated from the air, or by the abſorption which is partly continued by the roots. The privation of the contact of light, which has ſo much influence in tranſpiration, is the only cauſe of this change of ſtate.

33. As to the ſeaſon of winter, and the ſleep which vegetables experience during this ſeaſon, it is to be obſerved in the firſt place, that it occurs only in plants that live more than a year, and the duration of which varies from two to ſome hundreds of years. During this repoſe, the tree being deprived of its leaves, and reduced to its ſtalks and the buds which garniſh them, exhibits the image of apparent death; though, if compared with dead wood, there are very perceptible differences even in its aſpect. No ſap exiſts in the trunk or branches; it no longer tranſpires; it reſiſts the ſeverity of froſt, however, to a certain point, and while water freezes around it, the portion it contains remains fluid, in conſequence of its internal temperature, and of the portion of life it retains. No ſenſible change takes place in the ſleeping vegetable: the ſole effect of its life is confined at this time to the ſupport and very ſlow en-

largement of the leaf-buds and flower-buds, which cover all the points from which either are to iſſue. The form, poſition, and ſtructure of theſe buds may ſtill afford the botaniſt means or characters for diſtinguiſhing it, excluſive of the appearance of the trunk or branches. The root alone retains greater activity; it is more ſucculent, and larger than the reſt of the plant.

34. All the effects of the winter-ſleep are manifeſtly produced by the lowering of the temperature. The external cold allows the fibres and the ſides of the veſſels of plants to contract or cloſe together. The organs of tranſpiration no longer exiſt: the evacuation of vapour no longer taking place, the aſcent of the ſap itſelf is interrupted. The ſolid part, or ſupports of the vegetable, remain in a ſtate of reſt, inertneſs, and ſtationary inactivity, whence ariſe the abſence of every notable chemical change in its continuity, and conſequently a ceſſation of growth. A very ſlight change takes place in the buds alone, to which the ſmall quantity of thick fluid remaining in the veſſels flows, and in which it becomes concentrated, ſo as gradually to enlarge theſe germs, and ſlowly to bring on their development, and ſhooting forth at the firſt increaſe of the heat of the atmoſphere. Events paſs ſomewhat differently in evergreens, which keep their leaves during winter, and retain in the reſinous juices, with which they are humectated, while their

tranſpiration alſo is ſlight at all ſeaſons, ſufficient caloric to defend them from the ſeverity of the cold, and to keep up a remnant of life and motion, which, however, is much leſs than it is in hot weather. Still this difference in the ſleep of evergreens, which do not loſe their leaves, or rather this kind of natural ſleepleſsneſs, requires to be ſtudied, and may prove a ſource of new diſcoveries.

I. *Germination.*

35. THE germination of ſeeds, or the phenomenon by which the germ contained in a ſeed unfolds itſelf, and becomes a real plant, of which the root penetrates into the earth, and the ſtem riſes into the air, is one of the moſt admirable and aſtoniſhing phenomena which the natural hiſtory of vegetables diſplays. It is an aſtoniſhing ſpectacle to the philoſopher, as well as to the man of the leaſt enlightened mind, particularly when the feeble exiſtence of the ſeed is compared with the tree to which it gives riſe. Accordingly, in almoſt all ages, this phenomenon has engaged the attention of the greateſt natural philoſophers, and their ſucceſſive labours have at length lifted up the veil, which nature had thrown over one of her moſt myſterious operations. Malpighi and Grew were the firſt who deſcribed with care the ſtructure of ſeeds, and obſerved the circumſtances of their germination. The firſt picture which Malpighi

traced of it on the ſeed of a curcubitaceous plant is one of the moſt beautiful performances of vegetable phyſics. Grew has ſhown the relation of the cotyledons to the radicle, and the continuity of this with the plumes. Homberg ſaw in 1693, that germination does not take place in vacuo. Ray, Ledermuller, Adanſon, Bonnet, Bierkander, Ludwig, Krafft, Bohmer, have obſerved the greater part of its moſt remarkable phenomena. Achard, Ingenhouſz, and Sennebier have ſtudied its cauſes ſubſequently to the modern diſcoveries in chemiſtry, and have connected them with the data of this ſcience.

36. The vegetable ſeed, conſiſting of one or two cotyledons, of the radicle which has a communication with them by means of veſſels, and of the plume which is continuous with the radicle; covered with two coats, the exterior ſolid and hard, often horny, ſometimes woody, the interior thinner, doubling in, and enveloping the embryo completely formed and arrived at maturity, enjoys the property of germinating, and ſometimes retains it a long time. Every ſeed has its time and period of germinating, from a ſingle day, as certain grapes, to ſome years as the hazel nut. This function however, may be accelerated by various means, particularly by the action of oxigenated muriatic acid, as Mr. Humboldt has proved, who has propoſed this ſimple mean of raiſing in hot-houſes in botanic gardens ſuch ſeeds, as we have not yet been

able to make germinate. Every one knows that ſeeds germinate in the earth: there are ſome, however, which germinate in water, or in moiſt air. They are made to grow alſo on ſponges, tow, moſs, &c. All the organs of the ſeed, and their perfect integrity, are required for germination to ſucceed: the removal of the cotyledons renders it impoſſible.

37. The depth at which ſeeds are buried in the earth, requires to be in ſome degree circumſcribed, for their germination to be ſucceſsful. Placed too deep, the ſeeds do not germinate: at the ſurface, and when the cicatricula is not covered with earth, germination equally fails. A knowledge of all the conditions neceſſary to germination will explain the neceſſity of this diſpoſition, which is fully confirmed by experience.

Air muſt be in contact with the ſeed for germination to take place: and when the ſeeds are buried too deep, the air cannot penetrate the ſoil, which ought beſides to be well broken, to give paſſage to this fluid. The preſence of oxigen gas is indiſpenſably neceſſary: ſeeds do not grow in azote gas, or hidrogen gas; but if a certain proportion of oxigen gas be added to either of theſe, the ſeeds will come up. Water is no leſs neceſſary to germination: that which is impregnated with air promotes it much more than boiled water; and the addition of a little oxigenated muriatic acid accelerates it. We have no direct proof of the influence of electricity

city on this function, though it has been admitted by ſome natural philoſophers.

38. An increaſe of temperature greater or ſmaller, or a more or leſs conſiderable quantity of free caloric, is one of the moſt eſſential conditions of germination. Germination has never been known to take place below the freezing point, or at 0, of the thermometer: it does not begin, at leaſt for plants of which the ſeeds are known (for of the germs of the cryptogamia claſs we know nothing) but at 6° or 8° of the thermometer. But the requiſite degree of temperature varies ſingularly in the different ſpecies of ſeeds. In general a temperature exceeding 20° of Reaumur's thermometer promotes and accelerates the germination of ſeeds, which will germinate at a lower temperature: the contact of light retards, or completly prevents germination, which conſtantly takes place in darkneſs. Thus a ſeed well formed, thoroughly ripe, entire in its organization, committed to moiſt earth by which it is entirely covered, buried to a ſlight depth, ſufficient to deprive it of light and allow a paſſage to the air, moiſtened with a due quantity of water, expoſed to a higher or lower temperature according to its peculiar nature, undergoes the proceſs of germination, and in a determinate time gives birth to a plant ſimilar to that by which it was formed.

39. When all the conditions that have been mentioned are combined, the ſeed begins, ſometimes in a few hours, to have its coats moiſtened

by the water, which penetrates them, and likewiſe its cotyledons, which ſwell and ſoften: the circatricula enlarges and opens, the coats burſt, the radicle comes forth, and exhibits a little prominent knob, which ſoon lengthens: the ſubſtance of the cotyledons is then filled with a milky magma or pulp, of a bland ſaccharine taſte. Preſently the plume comes out, and exhibits the curved back of its ſtalk through the cleft membranes: it unfolds itſelf, and riſes towards the ſurface of the earth: the radicle grows larger on its part, its knobs extend, and become covered with little filaments. Both theſe parts conſtantly follow theſe directions, and bend in various ways to take them, whatever be the poſition of the ſeed. The plume, ſtrengthened though yet white and truly etiolated, pierces the ſurface of the earth at the end of a longer or ſhorter time, puſhing before it the cotyledons to which it ſtill adheres, and which, when once immerſed in the air, ſeparate from each other, diſplay themſelves in ſeminal leaves, and ſuffer the young plant, the point of which begins to change from white to green, to be ſeen between their parenchyma, which is withered and diminiſhed in thickneſs: preſently the cotyledons dry and fall off, when they are no longer neceſſary for its nutrition. In the monocotyledons the ſeed comes up and is carried laterally by the leaf rolled up conically or lengthened into a tongue, which ſhoots into the air.

40. Theſe

40. Theſe phenomena announce, that the water, which has paſſed through the coats, has ſwollen the lobes or cotyledons, has ſoftened and diluted the parenchyma, and has formed of it a kind of milk, which, being carried into the radicle by the veſſels of communication between theſe two parts, has extended, developed, and elongated it, ſo that it is continued out of the ſeed. This radicle, once ſwelled and diſtended in its internal texture by the milk of the nouriſhing lobes, tranſmits to the plume, the channels of which are dilated by the heat, the milky nutriment it has received: and the plume, injected as it were with this alimentary fluid, unfolds itſelf; all its veſſels, filled with juice, ſwell, and exhibit ribs or prominent lines on the leaves. This effect of nutrition, very rapid at the commencement of vegetable life, quickly raiſes and elongates the plume, which becomes a plant. Thus the radicle ſupplies it with the vegetable milk which it draws from the lobes, till its filaments grow larger, and form a number of mouths of ſufficient ſize and activity to draw from the earth the juices it offers. Then the young plant, hitherto ſupported by the proper ſubſtance of the cotyledons, beginning, when it has riſen into the air, to receive the influence of light and the heat of the atmoſphere, tranſpires copiouſly, and thus obliges the radicle to ſupply it from the earth with the fluid, which it requires for its growth. At this period the exhauſted co-

tyledons become uſeleſs, and fall off: the plant lives by its own powers.

41. All theſe effects are accompanied by chemical charges which produce them: the farinaceous feculent matter of the lobes or cotyledons, which is at the ſame time more or leſs oleaginous, being diluted by the water which the coats impart to it, forms a peculiar emulſion, which undergoes a real fermentation by means of heat: a ſaccharine matter is formed in it, the preſence of which is atteſted by its decided taſte in germinated ſeeds, particularly in thoſe that are termed corn: this matter contributes to the nouriſhment of the young plant: it is ſoon converted into ſap, and into the proper vegetable ſubſtance: its fermentation is accompanied with the formation of a certain quantity of carbonic acid, which is decompoſed in the young plant the moment it is ſtruck by the light, and yields to it its carbon the firſt principle of its commencing ſolidity. Thus, germination is effected by a chemical action or power, eaſily diſcovered and determined by phenomena fully obſerved; and the organization does not act its part, nor is the principle of life eſtabliſhed in the vegetable, till after the abſorption of water and caloric, the emulſive ſolution of the cotyledons, the formation of a muco-ſaccharine matter, and that of carbonic acid, the firſt impreſſion of which on the vegetative power of the plant begins with developing in it that irrita-

bility which grows with it. This ſimple and natural explanation of germination undoubtedly announces, that one firſt ſtep has been made in vegetable phyſics by means of the light which chemiſtry affords; but many others remain, that may be expected from the further progreſs of this ſcience.

K. *Foliation.*

42. Foliation, or *coming into leaf* as it is called, is the phenomenon by which leaves unfold themſelves, and ſpread in the air, either at a certain period of vegetation in annual plants, or at a particular period of each year in the perennials. This eruption of the leaves is one of the grand functions of plants, ſince theſe organs act a very important part in vegetable life, as has been ſeen. It is in ſome reſpect a ſecond germination: it is the formation of a part, which completes the organization neceſſary to the ſupport of theſe beings. The reſult of it is a multiplication, an extenſion of ſurfaces, which eſtabliſh a communication between plants and the air, the important conſequences of which are vigorous vegetation, and all the functions that accompany it. The leaves exiſt at firſt, completely formed, but very ſmall, and cloſely folded together, in buds of a particular ſhape

and ſtructure: at a certain temperature, which muſt be at leaſt of 10°. for moſt plants, and aided by the contact of light, the buds open by the ſeparation of the ſhells in which they were encloſed, and the leaves ſpread themſelves in the air.

43. The opening of the buds and ſeparation of the ſhells are manifeſtly owing to the motion of the ſap, which ſwell and diſtend their veſſels, as well as thoſe of the leaves. Theſe buds, during their hibernation or winter's ſleep, at firſt grow very ſlowly. The leaves injected by the ſap impelled forward or imbibed at firſt ſtep by ſtep, acquiring a greater increaſe in the ſpring, puſh out and ſeparate the ſhells, which kept them diſtinct and bound up: preſently they lengthen their foot-ſtalks, and ſhoot with rapidity into the air, with which they keep up an extenſive contact. From this time the ſtate of the plant is ſingularly changed. The expanded leaf at firſt aſſumes a pale green hue; ſtill retaining a yellowiſh tinge, it is filled with a mucous, glutinous juice of little taſte: when rubbed between the fingers it inviſcates them, and makes them ſtick together. This mucilaginous nature continues but a few days: the leaf, as it unfolds itſelf more, loſes this glutinous fluid. In proportion as its colour heightens, its parenchyma and leſs abundant moiſture become bitter, acrid, aſcerb, combuſtible, extractive, or aromatic, aſſuming in ſhort a different chemical character.

44. Theſe ſucceſſive changes, which take place in the leaves at the ſame time as the vegetable, grows, tranſpires, and decompoſes the water and carbonic acid in its organs, are irrefragable proofs that a chemical effect, a ſeries of decompoſitions and various combinations, take place in their veſſels, and particularly in their cells, which occaſions the difference of taſte, ſmell, conſiſtence, and colour, obſerved in their texture, from the commencement of foliation till the functions of the leaves terminate. It is even probable, that of all the organs of vegetables the leaves are thoſe, in which chemical attractions, and the changes that ariſe from them, take place with moſt energy; ſince theſe organs with their numerous and very diſtinct veſſels, exhibit in the net-work they form a pulpy, medulary, or cellular texture, very ſuitable to theſe effects, in conſequence of the room they afford, the fluids with which this texture is moiſtened, and and the ſtay they allow them to make.

45. Leaves offer to the obſerver another period, not leſs remarkable than that of their eruption, when they have fulfilled the functions which Nature has aſſigned them. Their colour, from a green more or leſs deep, gradually grows pale and diſappears, turning to a yellow or fawn colour, either all over at once, or in parts. They loſe their ſubſtance, and become thin: their freſhneſs and verdure diſappear: they grow darker coloured, and wither. Soon after theſe

changes their ſupport contracts, ſhortens, and dries, quits the part of the branch to which it adhered, and falling carries with it the leaf, already ſome time dead. It is ſcarcely neceſſary to remark, that this phenomenon of defoliation is accompanied by chemical changes, to which it even appears to be owing: the fluids have grown thick, and none reach the leaves at a certain period of their decay: tranſpiration then ſtops; and we ſee that the fall of the leaves is the ſignal of the ſlumber, that commences in the plant.

L. *Flowering.*

46. Flowering, or the formation and expanſion of the flowers, is one of the moſt important periods or events in vegetable life. As it is its principal purpoſe, it coſts many efforts; it exhauſts in ſome ſort the plants in which it takes place. All the work of vegetation that precedes it being deſtined to produce this flowering, when it has taken place, the plant is much weakened, and the remains of ſtrength it preſerves ſuffice only for fructification. To underſtand the connections of this function with chemical phenomena, I need only exhibit its moſt general reſults.

47. The flower, long prepared and organized in its bud, which is more round and diſtended

than that of the leaf, opens at a given temperature, which differs in different plants. As they follow an order of days in their ſucceſſive expanſion, the flowers of a diſtrict furniſh botaniſts with a calendar of Flora. After it has opened, the petals of the corolla become coloured; the influence of the air and light is of great importance in producing this colour: an excretion of ſaccharine matter takes place in a particular point of the corolla, which is called the *nectary*: odoriferous effluvia frequently emanate from the petals, which conſtitute a perfume more or leſs prized. The ſtamens, or male organs, commonly approach the piſtil or female organ, and ſhed their fecundating duſt on the ſtigma. A matter, probably of a vaporous nature, traverſes the ſtyle, and proceeds to ſtrike or impregnate with vitality the ſeeds placed in the ovary. This function once fulfilled, the anthers dry, the filaments of the ſtamens wither, the petals wrinkle and drop off, and the fructification commences.

48. In this ſucceſſion of remarkable phenomena, which conſtitute flowering, we cannot overlook a ſeries of chemical operations. Each part of the flower is continuous with a correſpondent organ, from the calyx which is propagated from the bark, to the piſtil which confounds itſelf with the extremity of the medullary texture. The juices are prepared before they arrive at theſe parts; but they unqueſtionably

undergo ſome modification, a ſecond and definitive elaboration, in the organs of the flowers. The fecundating duſt of the anthers, termed *pollen* by botaniſts, the aromatic honey of the nectaries, the odoriferous vapour of the petals, are ſo many products of this chemical elaboration. The colouring of the corolla by the air is equally a conſequence of chemical alterations, which the flowers experience in their texture. We know nothing yet of the cauſe of fecundation: it is not impoſſible that it may be concealed in ſome effect of chemical affinity, which has hitherto eſcaped the reſearches of naturaliſts.

M. *Fructification.*

49. When fecundation has taken place, and the organs that have effected it, as well as thoſe which ſurrounded and protected them, have diſappeared or fallen off as mutilated, the fertile ſeeds gradually enlarge in the ovary, the fruit is formed, and acquires a more or leſs conſiderable growth. This furniſhes itſelf with pulp, fleſh, mucilage, parenchyma, huſk, membranes, ſhell, kernel, and all the moſt varied kinds of envelopes, intended to cover and preſerve the ſeed to perfect maturity. Moſt of theſe acceſſaries ſerve at the ſame time to nouriſh the ſeeds, to ſupply them with aliment ſuitable to their nature, or to

afford the veſſels which convey it a ſupport, and perhaps impart a peculiar nature to them. This fleſh or pulp of fruits is ſweet, ſaccharine, acid, flat and mucous, bitter and acrid, oily, aſcerb, and in general of very various taſtes and chemical properties.

50. Who does not ſee, in this work of fructification, the reſult of a chemical power and action, as well as in the growth and nutrition of the different parts, particularly of the lobes or cotyledons of the ſeed? A conſtant identity of effects gives birth in the internal part of the fruit, or in the ſeed, to the formation of fecula, fixed oil, and gluten, ſince all ſeeds uniformly exhibit one or other of theſe principles: but a great variety of chemical compoſitions or productions prevails in the pulp or parenchyma of fruits. The regularity of the former reſult, and the variety of the latter, certainly depend on the ſtructure and different organization of theſe two kinds of parts. Beſides, external circumſtances, the rays of the ſun, the temperature, the dryneſs or moiſture of the air, the winds, water, influence the nature of the parenchyma of fruits, which are always expoſed to them; while the more important fate of ſeeds, of which fruits are but the defending coats, is entruſted to an interior organization, a central, choice, and regular ſtructure, always the ſame, never variable, and which cannot be modified by external accidents.

ARTICLE X.

Of the Modifications which Art produces in Vegetables, of the principal Changes of which they are ſuſceptible, and of the Diſeaſes by which they are affected.

1. FROM the particulars contained in the preceding article it appears, that vegetables are real machines, in which many chemical operations take place, conſiſting generally in triple combinations at leaſt of the primitive principles furniſhed by the earth. Accordingly, they are liable to be greatly affected by all external ſubſtances. It is from the influence of theſe, directed according to the will of the cultivator, that plants experience modifications and changes, the production of which augments the enjoyments of man: long experience has certified and multiplied theſe modifications, ſo that they are become the object of an art of great importance in ſociety, which includes agriculture among its various practices.

2. The purpoſe of cultivation is to multiply vegetables, the properties of which fit them for the food of man, his clothing, the conſtruction of his habitations, the mitigation of his diſeaſes, and the gratification of his ſenſes, particularly

thoſe of ſight, taſte, and ſmell. Vegetables are multiplied either by ſowing or planting ſuch as nature offers ſingly, rare, or in little abundance. Cultivation propoſes not ſolely to increaſe the quantity of theſe uſeful beings in the proportion our wants require, but to make them grow in the ſhorteſt time poſſible, ſheltered from the dangers to which they are liable, and in the greateſt poſſible quantity on a given ſpace. It attains this object by chooſing the ſoil ſuitable to each particular ſeed and plant, preparing it by the ſpade or the plough, enriching it by burying in it vegetable or animal matters, removing the injurious plants which grow in it ſpontaneouſly, and giving, either to the ſoil or to the plant committed to it, from the moment of ſowing or planting to that of gathering the produce, all the treatment capable of favouring the growth and multiplication of the vegetable. It varies its means, according to the nature of the ſoil, and of the plants cultivated in it, conformably to the order of the ſeaſons, and the temperature and aſpect of the place.

3. The object of agriculture, conſidered in the great, is likewiſe to furniſh a ſufficient abundance of food for animals uſeful to man; to enable them to repay the earth what they take from it by conſuming its produce; and the ſcience and great ſucceſs of this firſt of arts truly conſiſt in the exact proportion of animal

to vegetable productions. It is carried toward perfection when theſe two kinds of productions are ſo well regulated and arranged in their mutual relations to each other, that nothing is wanting to theſe animals, and that they furniſh a proportion of manure more than ſufficient to continue that fertilization, of which they afford a conſtant ſource in their excrements and litter. Thus by inceſſantly renovating the fertility of the earth, this in return ought to give them what is neceſſary to furniſh man with wholeſome food, materials for clothing him, and aſſiſtance to convey his burdens, to till the ground, and for all the purpoſes to which animals are applied in a domeſtic ſtate.

4. The numerous experiments which have been made in a long ſeries of ages on the culture or multiplication of vegetables by art, have led to a number of reſults, not leſs intereſting in the natural hiſtory of vegetables, than uſeful to the wants and taſtes of civilized man. Theſe have taught us to multiply trees and plants by grafts and layers; to enlarge their ſtems; to ſpread, blanch, or colour their leaves; to alter their fruits in ſize and flavour; to double their flowers; to croſs their breeds, and produce mule plants; and to eſtabliſh varieties, which nature had not given to man, and which, being perpetuated by cultivation, have received and merit in agriculture the name of *ſpecies*. The arts of manuring land, of grafting, pruning, and

laying down trees, of ſheltering them and ſupporting them in eſpaliers and againſt walls, of giving them ſuch a form in height or ſpread as ſuits the place where they are planted, of accelerating or retarding their maturity, of varying the taſte, ſize, and ſhape of their fruits; that of producing in a temperate or cold climate in hot-houſes, in hot-beds, under frames, under bell-glaſſes, in hot and factitious earths, plants which nature placed only between the tropics, or under the equator; that of varying the colours and perfume of flowers, of doubling them, or converting their ſtamens into numerous coloured petals: all theſe wonders of cultivation, which vary and multiply our enjoyments, are capable of being explained or underſtood by means of the chemical notions that have been developed in the preceding articles.

5. In fact, it is by increaſing nouriſhment, by the addition of abundant manure; haſtening vegetation by an artificial and increaſed temperature; opening the boſom of the earth by frequent and deep ſtirring to the beneficial influence of the light and air; conveying to it by irrigation, trenches, or the watering pot, an abundance of water, which the atmoſphere withholds too long, or furniſhes in too ſmall quantity; fecundating one ſpecies of flower with the pollen of another nearly allied to it; impregnating water with a very nutritious vegetable juice, very ſuſceptible of fermentation

and heat; ſtopping the motion and courſe of the ſap in ſome parts of the plant by bending it, tying it, or cutting the bark; forcing a portion of one tree, or bud-bearing bark, to inſert itſelf into another, and live at the expenſe of its juices, after having agglutinated or made it unite into one ſubſtance with it by grafting; conducting all the nutriment to the fruit-buds, by removing ſome branches which would conſume too much ſap; adding to the earth ſtimulants, which, being conveyed into plants with the water that their roots imbibe, give activity to their vegetation: in ſhort, by employing a great number of proceſſes and agents truly chemical, the cultivator, frequently even without having any conception of the cauſe or mode of action, but always guided by practice of more or leſs continuance and ſucceſs, produces all the changes and modifications that anſwer his wiſhes.

6. But all theſe firſt data, all the applications of chemical ſcience to the phenomena of the artificial cultivation of vegetables, are yet only the firſt glimpſes or perceptions, the exiſtence and importance of which have been conceived or even ſuſpected by the moderns alone. Wallerius had already laid ſome of the foundations of agricultural chemiſtry; Bergman had carried them a little farther in turning his attention to earths; and Lavoiſier has ſince diſplayed all its importance. Theſe firſt ideas have yet

ſcarcely excited the attention of a few of the inhabitants of the country: when will enlightened citizens, weary of the tumult and factitious pleaſures of cities, carry into the country the knowledge with which their minds are ſtored, and apply to agriculture the rich reſources of phyſical ſcience!

7. The deſtiny of plants, conſidered as chemical implements employed by nature to form the firſt triple or quadruple compounds, to unite by complex attractions at leaſt three primitive ſimple ſubſtances, and often more, muſt be to change perpetually their ſtate, to remain but a little while in the ſame order of compoſitions, and to experience, from the very nature of the multiplied powers which re-act on their principles, variations that more or leſs profoundly alter their materials. If the external circumſtances, if the exterior agents, which influence, as has been ſhown, their intimate nature, come to experience ſudden and great alterations; if the air change quickly from temperate to cold, from dry to moiſt; if it ſtrike plants too rudely; if particularly it be too long loaded with water; if froſt unexpectedly ſucceed mild weather after the firſt efforts of vegetation in ſpring; if a violent wind carry off too abundantly from the leaves, as well as from the earth, the water which circulates in the former and humectates the latter; if after rain, a burning ſun dart on vegetables covered with

water, each drop of which concentrates its rays like a lens; if the deluged ground do not allow too large a body of water to flow off, all theſe cauſes, and a great number of others, become ſo many ſources of alterations more or leſs injurious to plants, and diſeaſes are produced in them, as well as in animals.

8. It even ſeems, that, modified by our cares, rendered more ſenſible and delicate by culture, participating in ſome degree the inconveniences of that ſort of domeſtic life or civilization to which we have brought them, plants, like ourſelves, and like domeſtic animals, are more expoſed to indiſpoſitions and diſeaſes than thoſe which grow ſpontaneouſly in the places man has ſtill left to nature. It is rare that the ſame number, and particularly the ſame kinds of diſeaſes, attack the trees of the foreſt, as thoſe which very frequently we ſee only in our orchards. The plants of our fields, eſpecially our corn, are affected with diſeaſes, which we ſcarcely ever, if at all, obſerve in thoſe that grow wild. It may be ſaid, that their multiplication, and their being crowded together in one ſpot, and in too confined a ſpace, ſometimes occaſion them the ſame injury, as men and animals experience from the incumbrances and throng of too cloſe a place. It is true, on the other hand, that the care of the cultivator protects them from the teeth and ſtings of animals and inſects, to which nature expoſes

the vegetables ſhe produces, and for which ſhe even appears to have deſigned them. But the greatneſs and danger of the diſeaſes, in ſome ſort to be conſidered as ſocial, and frequently endemial or even epidemic, which attack the vegetable tribes cultivated in our fields, do not allow us to imagine that there is, in this reſpect, a compenſation favourable to the cultivator.

9. Without giving here an enumeration, which would be out of place, I ſhall content myſelf with obſerving, that, notwithſtanding the little care that has been taken to diſtinguiſh and deſcribe all the diſeaſes of plants, we know enough to perceive, that no vegetable, and no part of a vegetable, is exempt from them. The trees of orchards, gardens, parks, avenues, and highways, frequently ſhow their bark cleft and cracked, corroded by dry or moiſt ulcerations, enlarged by tumours, pierced and diſſected by inſects, torn by beaſts, exhauſted by paraſitical moſſes and lichens. Their wood bends, ſplits, dries, ſwells: we ſee it attacked by *mouldineſs*, *ulcers*, *excreſcences*, *knobs*, and *wounds*. The leaves of plants are liable to *mildew*, *blaſt*, *blight*, *parching galls*, *premature decay*, *loſs of colour*, *curl*. The enemies and ravagers of our harveſts, and the graſs tribes, are the *ſhedding of the grain*, *caries*, *horn*, *and ſmut*. In all theſe caſes, already obſerved with ſome care, we ſee the organs of vegetables

change their figure, conſiſtency, colour, taſte, and ſmell, and conſequently their chemical nature.

10. Who will deny that all theſe diſeaſes are accompanied by chemical changes and accidents, which we ought to conſider not only as their effect, but often as their cauſe? Has it not been found, that in ſmutty, carious, and horned rye or wheat, there no longer exiſts any amylaceous or glutinous ſubſtance, but here an oily fluid, there an acrid and coaly extract? Are not wood and bark, when ulcerated and covered with a blackiſh ſanies, or whitiſh, gritty, and dried cruſt, loaded with acetite of lime and of pot-aſh, tannin, reſin, and carbonate of lime and of pot-aſh, according to the experiments of Citizen Vauquelin? Who can limit the capacity of chemiſtry for acquiring a knowledge of the nature, cauſe, and remedies of theſe diſeaſes? Let us hope, that, with all the lights which this ſcience affords to agriculture, this inveſtigation will no longer be neglected: let us truſt, that this pleaſing taſk, begun under ſuch happy auſpices, will no longer be delayed; and let us depend on thoſe ardent, ſtudious youths, who will carry with them into the country uſeful knowledge, and who will not allow the firſt of arts to remain chained down to blind cuſtom, to prejudices deſtructive of every thing that is good. In fine, let us be perſuaded, that the period, when the labours of

the field will be benefited by the knowledge hitherto confined to cities, cannot be remote, under laws that diffuſe inſtruction through all ranks of ſociety.

END OF THE EIGHTH VOLUME.

W. Flint, Printer, Old Bailey.

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